POWER

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Service

WHEN you buy a piece of engineering apparatus you buy not so many pounds of steel or brass, but, if you are dealing with the right kind of people you buy service.

That apparently simple contrivance may embody years of search for materials particularly adapted to the requirements that it must meet, of expensive experiment as to the form and disposition best suited to withstand the severities of its service, of costly supervision while it was working itself out under the conditions of practical operation.

This kind of stuff cannot be sold by the pound—but it costs money.

It is of more importance to the maker of engineering goods that his product already sold is understood and used intelligently and satisfactorily than that he gets a new order.

And he must keep it sold and satisfactory by first seeing that it is adapted to the service that is expected of it and then that it is kept in condition to perform that service.

He must hold his trouble man at your call and will, likely of his own volition and at his own expense, assure himself from time to time that the product that he has sold you is working as it should.

The customer should not only appreciate the cost and value of this kind of service, but should treat the installation from his side with the same generous disposition.

If it does not do what he expected of it, what it promised to do when he put up the money for it, he is a loser.

It is worth his while to make the apparatus a success and himself a winner.

This does not mean that he should excuse remissnesses of the seller or remit responsibilities that the seller has assumed. But he can give the apparatus a fair chance. He can insist upon proper care being given to it, and when it goes wrong or anything happens to it, he can let the dealer that is responsible for its performance put it back into what he knows is the proper condition.

One would not send his indicator around to a local machine shop to be reamed out in case the cylinder got scarred, but things almost as egregious are done every day. When you get castings from a local foundry to replace broken or burned out parts, do you know that they are as fit for the purpose as those the dealer could supply?

If you were the dealer, would you care to continue to be responsible for the satisfactory performance of your apparatus, parts of which another had replaced?

But the dealer cannot escape the responsibility, for when a crash comes or maintenance charges mount up high, it is not the reputation of the local job shop that suffers.

If you accept the service that goes with the sale, but feel that further service you must purchase elsewhere, it is only fair, is it not, that you insist upon a grade of both work and materials that will maintain the integrity of the apparatus?

F. R. Low

Steam Power from Blast-Furnace Gas

BY GORDON FOX* AND F. H. WILLCOX†

An interesting résumé on the utilization of blast-furnace gas for steam making and the development that has taken place in burning the gas alone or in combination with other fuels. Typical data are given as to the amount of gas available and the variation in the supply. The importance of cleaning the gas is emphasized, numerous recent installations are cited and the developments in design are summarized.

THE blast furnace is primarily a producer of iron. Secondarily, it is a producer of gas, which plays an important part in its operation and economy. This gas analyzes approximately as follows: CO, 23 to 26 per cent; CO_2, 15.5 to 12.5 per cent; Hydrogen, 3 per cent; Nitrogen, 58.5 per cent.

For each pound of coke charged into the blast furnace, there is produced about 71.5 cu.ft. of gas, which is conducted from the top of the furnace under its own pressure, which may vary over a wide range, from 4 to 30 in. of water. The gas is at a temperature of 225 to 550 deg. F. or higher in some cases, and has a heat value of from 82 to 102 B.t.u., an average value being 94 B.t.u. The gas contains a quantity of dust in suspension, largely coke and ore dust, to the extent of 2 to 7 grains per cubic foot, which is too dirty for use either in the furnace stoves or under boilers.

Practice varies as to the extent to which the gas is cleaned. By passing it through dry dust catchers or whirlers or both, the dust content may be reduced to about 1.75 grains per cubic foot. This gas may be burned either in the stoves or under boilers. However, it is the prevailing practice to clean at least the stove gas and frequently all the gas by passing it through a cleaner, usually of the water-spray type. The gas delivered by an effective wet washer does not contain more than 0.2 grain of dust per cubic foot, and can be used effectively in stoves having small checkers and is an excellent fuel for burning under boilers.

As a result of furnace operation the gas produced fluctuates, particularly as to volume and pressure. The volume fluctuations are shown by the curve, Fig. 1, which is based on 30-min. readings from a furnace producing 430 tons of iron per day. In addition to the periodic fluctuation in gas volume, there is an almost total cessation of gas production for a short period when the furnace is cast. This occurs from four to six times per 24 hours. Each cast interval lasts about three minutes. At these periods the blast is practically shut off. A 600-ton blast furnace producing normally about 55,000 cu.ft. of gas per minute, will deliver only about 3,000 cu.ft. per minute during the cast intervals. If a Berg mud gun is used for stopping the tapping hole, it is not necessary to remove the blast entirely, and gas production may be maintained during cast intervals at a rate of about 15,000 cu.ft.

Values involved in the utilization of the gas from a blast furnace may be seen in a tangible way from the typical case presented in the accompanying table. Consider a furnace producing 600 tons of iron per day. This furnace is equipped with washers to clean all the gas. Turbine blowers supply the blast. All surplus gas is utilized for generation of electric power, a portion of which is consumed in operations about the blast furnace.

TYPICAL DATA RELATING TO USE OF GAS FROM 600-TON FURNACE

Iron production per day, tons	600
Coke per ton of iron, lb	1,950
Gas per pound coke, cu.ft	71
Gas per minute, cu.ft	58,000
B.t.u. per cu.ft. gas	94
Gas losses, 5 per cent, cu.ft. per min	2,940
Gas required for stoves, 27 per cent, cu.ft. per min	15,000
Gas available for boilers, cu.ft. per min	40,000
Boiler efficiency, per cent	65

Steam available at 225 lb. gage and 125 deg. F. superheat =

$$\frac{40{,}000 \times 60 \times 94 \times 0.65}{1096.9} = 134{,}000 \text{ lb. per hr.}$$

Equivalent evaporation from and at 212 deg. F. =

$$= \frac{40{,}000 \times 60 \times 94 \times 0.65}{970.4} = 151{,}000 \text{ lb. per hr.}$$

Steam required:	
One turbo-blower, lb. per hr	40,000
All auxiliaries, including boiler-feed pumps, air compressor and service pumps, lb. per hr	25,000
Available for electric power, lb. per hr	69,000
Kw. equivalent at 16 lb. per kw.-hr	4,300
Electric power required for furnace operation:	
Pumps, kw	450
Ore handling, cranes, pig machine, miscellaneous, kw	350
Total, kw	800
Surplus electric power, kw	3,500

Blast-furnace gas is relatively lean, having a heat value of about 94 B.t.u. per cubic foot as compared with about 550 B.t.u. per cubic foot for coke-oven gas and 1,000 B.t.u. per cubic foot for natural gas. Because of the large bulk per unit of heat, it is not feasible to store blast-furnace gas to any considerable extent. For this reason it is necessary to utilize the gas practically as produced. On the other hand, the electric power cannot be stored, but must be produced at the instant of demand. It is obviously impossible to have the supply of gas and the demand for power coincide. A common practice in the past has been to utilize less than the total available gas to insure a sufficient supply at all times, the margin over and above requirements being wasted. To utilize the gas more fully, coal firing may be employed during intervals when the gas

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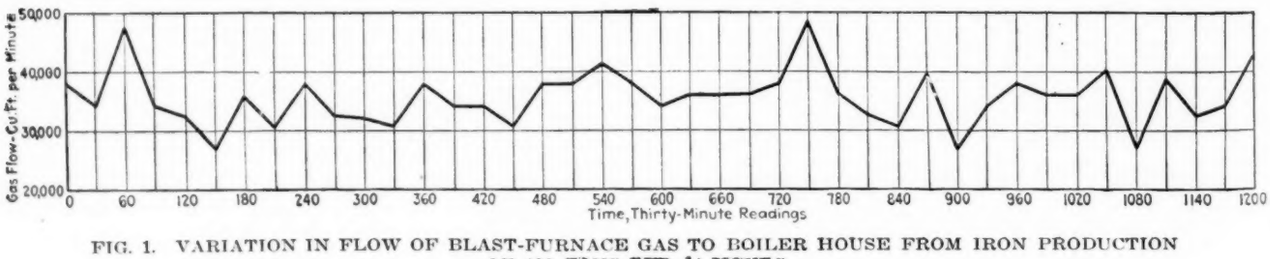


FIG. 1. VARIATION IN FLOW OF BLAST-FURNACE GAS TO BOILER HOUSE FROM IRON PRODUCTION OF 430 TONS PER 24 HOURS

supply is not sufficient to meet the power demand. It is obvious that in a plant where several blast furnaces are operated, the diversity factor will serve to render the gas supply more uniform. In a plant having but a single furnace, the situation is more complex.

Fuels that may be employed economically for auxiliary firing are: coal coke braize, coke oven gas and oil. The degree to which provision is made for auxiliary firing depends upon the extent to which this class of firing will be employed. This, in turn, depends upon the amount of fluctuation in the electric load and in the gas supply and also upon the relation between average power developed and average gas available. In case the full possibilities of the gas supply are not utilized, a relatively small amount of auxiliary firing will be necessary. When the load demand is greater than the available gas can develop, a large amount of auxiliary firing may be required and the station takes on the nature of a combined gas and fuel plant. A number of possible boiler-firing combinations will be enumerated and their advantages and disadvantages suggested.

An installation having a low first cost can be made by equipping all boilers for gas and installing grates for hand firing of coal. The boilers are then operated at a high rate with combined gas and coal firing. With this arrangement it is possible to utilize all the gas and during the low-gas periods to develop capacity with hand-fired coal. The disadvantage of this arrangement lies in losses and inefficiency incident to hand firing, together with high labor costs of manual firing and handling of coal and ashes.

A similar installation may be made but operated differently in that the coal firing may be restricted to separate boilers. With this combination all the available gas may be utilized if there be sufficient demand for steam. The efficiency of gas firing may be well maintained, and the fluctuations in the supply taken up readily by the coal-fired boilers. The efficiency of the coal-fired boilers will be low, however, and a large number of boilers will be required, due to the transfer of load from gas-fired to coal-fired boilers at intervals.

A combination involving the simultaneous firing of blast-furnace gas supplemented with coke-oven gas, tar or fuel oil, may be employed. This arrangement permits operation of the boilers at high efficiency. A minimum of boiler capacity is required. Fluctuations in blast-furnace-gas supply can be quickly equalized with the auxiliary fuel. Convenience and low labor costs also accrue. The principal disadvantage to this method is the high unit cost of the auxiliary fuel, particularly if oil is used. It offers advantages in simplicity and low first cost in cases where little auxiliary firing is necessary or where the auxiliary provision is largely for stand-by service.

Another possible arrangement contemplates the concentration of gas firing on a portion of the boilers supplemented by coal firing under separate boilers equipped with stokers. This arrangement affords good operating efficiency and low labor cost. It does not permit, however, under normal operating conditions, working the boilers at high rating, and the low combined load factor necessitates a rather heavy investment in a large number of boilers. As the gas-fired boilers assume the burden of the load most of the time and as the coal-fired boilers assume the load for short periods, a relatively larger boiler capacity must be operated. As provision must be made for cleaning and overhauling either gas- or stoker-fired boilers, some additional capacity must be provided with both gas burners and stokers for use with either fuel. The arrangement mentioned is particularly effective where the power demand is greater than the equivalent gas supply and where considerable coal firing is necessary at all times.

FIG. 2. TYPICAL INSTALLATION OF BLAST-FURNACE GAS BURNERS AT REAR OF BOILER SETTING

An arrangement that has advantage from the operating viewpoint contemplates the equipment of all boilers with both gas burners and stokers. The boilers are then fired in combination. When a fuel-gas supply is available, the stoker may be practically banked, operating at low speed and carrying only sufficient fuel bed to protect the grates and to maintain a going fire. A short time before the casting period the stoker is speeded up and sufficient fire developed to maintain the load. It is also possible with this combination to operate the boilers at high rating, firing both gas and coal in combination and to assume all the load on the

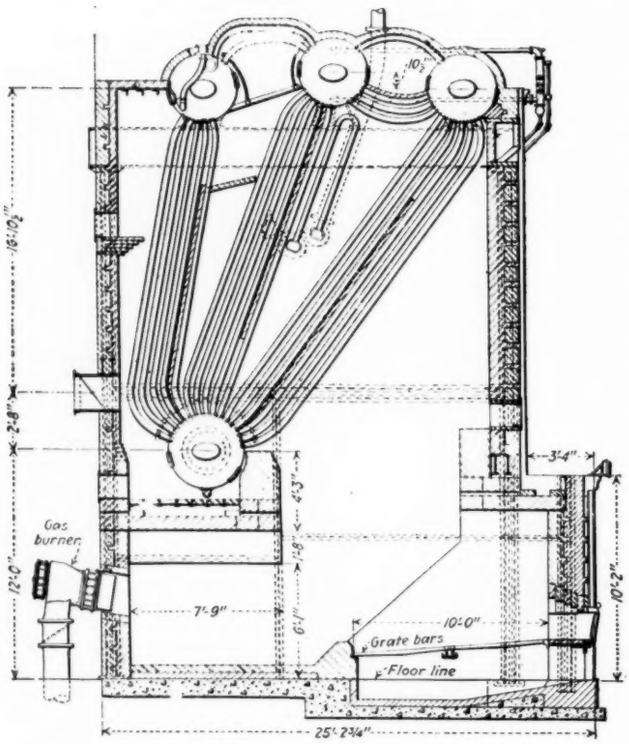


FIG. 3. DESIGN OF SETTING FOR BURNING BLAST-FURNACE GAS IN COMBINATION WITH COAL ON HAND-FIRED GRATE

stokers when required. The principal objection to this type of installation is the rather high cost of boiler units equipped with both gas burners and stokers.

Pulverized coal offers some advantages for use in combination with blast-furnace gas. Both fuels require a large combustion chamber. Pulverized fuel can be adjusted quickly to assume its portion of the load. The efficiency is high and the labor cost low. The high first cost of the fuel-preparation plant may be prohibitive, however, unless a considerable amount of coal firing is contemplated. It has been suggested that a small preparation plant may be installed, operating continuously at a good load factor. Sufficient storage may then be arranged so that the intermittent demand may be supplied. The use of pulverized fuel offers the advantage that one preparation plant may serve a number of boilers. The cost of burner equipment for each boiler is not a large item. In the case of stokers the full cost is repeated for each boiler, so that the installation must be restricted in order to obtain a reasonable load factor on the amount of equipment installed. In the case of pulverized fuel proportionately more boilers may be equipped with coal burners and greater flexibility obtained with possibly a lesser number of units.

A boiler fired by blast-furnace gas may be expected to develop about 135 per cent of rating as an average demand and will carry as high as 180 to 200 per cent of rating during the peaks. Stoker-fired boilers in plants of this type are commonly operated at 200 to 225 per cent of rating. Where combination gas and stoker firing is practiced, the gas will develop about 125 per cent of rating and the auxiliary fuel about 75 per cent of rating, the combination resulting in a 200 per cent operating rate. During intervals of deficient gas supply the stokers will assume all the load and develop 200 per cent of rating.

For the proper firing of blast-furnace gas, burners are required that will mix the gas effectively with the proper amount of air for combustion. Each furnace is equipped with a number of such burners. A battery of Birkholz-Terbeck burners, which are much used in this service, is shown in Fig. 2. In this type of burner 70 to 90 per cent of the air required for combustion is aspirated by the gas due to its pressure and velocity. This is mixed with the gas within the burner, a whirling action giving a particularly intimate combination. Blast-furnace gas may be fired efficiently with a burner of this type. In good practice as low as 10 to 15 per cent of excess air is obtainable. This corresponds to about 23 to 24 per cent CO_2 in the gases of combustion. Combined boiler efficiencies of 70 to 72 per cent are representative.

Large Combustion Chamber Desirable

It should be stated that the volume of the gases of combustion is 15 to 20 per cent greater with blast-furnace gas than with coal firing; therefore the stacks and breeching must be proportioned accordingly and the boiler baffling suitably disposed to care for this condition. A large combustion chamber is desirable, having a volume of 2.5 to 3 cu.ft. per 10 sq.ft. of steam-making surface. This volume is approached in coal-fired boilers of only the more modern designs, intended for high ratings. Under a gas-fired boiler the furnace temperature is about 2,200 deg. F., as contrasted with about 2,700 deg. with coal firing. The radiation losses are therefore slightly less and the cost of brickwork maintenance is not excessive.

Among the most recent furnace plants that have been equipped with gas-fired boilers, are the following: Wierton Steel Co., Wierton, W. Va.; Steel and Tube Co. of America, Indiana Harbor, Ind.; Republic Iron and Steel Co., Youngstown, Ohio; St. Louis Coke and Chemical Co., Granite City, Ill.; Ford Motor Co., River Rouge, Mich.; Trumbull Cliffs Furnace Co., Warren, Ohio.

At the boiler house of the Wierton Steel Co. the initial installation consisted of eight 6,000-sq.ft. three-pass Stirling boilers. Seven of these are equipped with gas burners and grates for hand firing. One boiler was equipped with a stoker for rapid supplementary steaming. A number of similar boilers with stokers have been added to assist in carrying the increased steel-mill load, the demands of which exceed the gas supply. There is fired on these stokers a quantity of coke braize incident to the blast-furnace operation.

At the Mark plant of the Steel and Tube Co. of America the initial installation included twelve 6,000-sq.ft. boilers in two groups. One group comprises six Casey Hedges boilers equipped for burning coal on

chain-grate stokers. The other group consists of six Stirling boilers, four of which are equipped with chain-grate stokers and two provided with grates for hand firing. All six Stirling boilers are equipped to burn blast-furnace gas, each boiler being provided with four 10-in. B.-T. burners located above the grates and directed into the combustion chamber, and each boiler is provided with its individual stack. Each of the six coal-fired boilers has two B.-T. burners for firing coke-oven gas during periods of surplus, mainly week-ends.

There are being added at this plant, six 6,000-sq.ft. Stirling boilers equipped with B.-T. gas burners and grates for hand firing. When these are installed, more of the original boilers will be restricted to coal firing.

The electric power required for this plant is greater than can be supplied from the gas available from the one blast furnace. The stoker-fired boilers carry the excess. The stokers on the gas-fired boilers are operated primarily to protect the grates and to maintain a going fire between casts. Operation at about 150 per cent of rating is maintained. Shortly before cast time these stokers are speeded up, maintaining the load on the gas-fired boilers.

A new boiler house has been installed at the Republic Iron and Steel Co.'s plant to utilize the gas from their No. 5 blast furnace. This house is equipped with four 12,500-sq.ft. Stirling four-pass boilers connected to a common stack. Each boiler is provided with 9 B.-T. gas burners. No provision is made for auxiliary firing of these boilers. A fifth boiler, also of 12,500 sq.ft. of surface, is installed, however, and equipped with stokers. This unit supplements the gas-fired boilers and is also connected with the older boiler house which, in turn, utilizes gas from blast furnaces Nos. 1 to 4.

Coke-Oven-Gas Burners for Emergency

At the St. Louis Coke and Chemical Co. plant the boiler installation comprises seven 8,000-sq.ft. Heine boilers equipped with grates for hand firing coal and burners for blast-furnace gas. Three of the boilers also have coke-oven-gas burners for emergency use. Provision is made so that the grates may be replaced by stokers when desired. No electric power is generated at this plant, but about 55,000 lb. of steam per hour is supplied to the coke ovens in addition to the blowing-engine and pumping requirements at the blast furnace, a portion being used elsewhere in the plant.

The recent installation at the River Rouge plant of the Ford Motor Co. is of particular interest owing to the large size of units and the use of pulverized coal for combination firing. Four Ladd boilers are installed at the new boiler house. Each boiler has 26,470 sq.ft. of heating surface. The boilers, which are built to generate steam at 240 lb. pressure and 200 deg. of superheat, are equipped with two sets of burners on either side for burning pulverized coal, either separately or in combination. The combustion space is particularly liberal, being 0.5 cu.ft. per square foot of steam-making surface. These boilers have developed 175 per cent of rating when burning blast-furnace gas, and with coal firing it is expected to develop about 275 per cent of rating. For a more complete description of this plant see *Power*, issues of Sept. 6 and Nov. 1, 1921.

One of the most recent installations of this kind is at the plant of the Trumbull-Cliffs Furnace Co., Warren, Ohio. The boiler house contains five 8,000-sq.ft. Stirling boilers, each equipped with grates for hand firing of coal as well as gas burners for blast-furnace gas. The design is of particular interest in that the coal firing is at the front of the boilers and the gas firing at the rear. This arrangement affords an effective coal-firing layout with additional furnace volume and flame development afforded for the gas. A rear view of the boilers, showing the burners, is shown in Fig. 2 and a vertical section of the setting in Fig. 3. These boilers have bulb beam construction of the front walls to reinforce them against local gas explosions.

The arrangement is such that the hand grates may be replaced by stokers when required. At present it is intended to develop only sufficient electric power to meet the requirements at the blast furnace, excess gas being wasted. Provision has been made throughout, however, so that additional turbo-generators may be installed and electric power generated to the full extent of the available gas. This plant is complete, but has not yet been placed in service owing to the business depression.

Gas-Engine Installation

In connection with the development of electric power from blast-furnace gas, the question often arises as to whether it is more advisable to install gas engines for blowing and for driving generators than a steam-boiler plant with turbine-driven blowers and generators. The gas engine retains popularity at some of the larger plants, where a large number of furnaces insure a fairly regular gas supply. At the smaller plants the installation of gas engines is usually considered inadvisable as the intermittent nature of the gas supply may not permit complete utilization and a supplementary source of fuel for the gas engines is seldom feasible. It is of interest to notice, however, that one of the larger plants, equipped with gas engines, has recently maintained a curtailed operation, utilizing gas engines in connection with a single furnace, restricting the load and curtailing the stove heats during the low-gas intervals.

In a paper presented recently by Mr. Petty, of the Bethlehem Steel Corporation, before the Association of Iron and Steel Electrical Engineers, curves are given showing that, with high-priced fuel and a high load factor, the total cost of electric power developed by gas engines is about 0.1c. cheaper than steam-generated power. With low-priced fuel and lower load factors, such as generally prevail in the smaller steel mills, the margin disappears or may even favor the turbine. By installing waste-heat boilers to salvage some of the heat in the exhaust gases, the economy of the gas engine can be appreciably improved. However, this practice has not yet been adopted in this country.

In the final analysis the efficient utilization of blast-furnace gas requires that all the gas be effectively employed. A station equipped with gas engines only cannot well utilize all the gas as some margin in supply is necessary. The practice has been followed in several instances to install gas-engine capacity to handle the bulk of the load, supplemented by steam turbines and boilers arranged for both gas and coal firing, the latter handling the marginal fluctuations in gas supply. The next article will deal with the combustion of blast-furnace gas under boilers.

Cooling-Water Systems for Internal Combustion Engines

By EDGAR J. KATES

ONE of the important factors in the satisfactory operation of any internal-combustion engine plant, and one which is too often neglected, is a suitable jacket-water system. This is the system of tanks and piping through which a supply of water is furnished to the engine jackets for the purpose of removing from the interior walls of the engine the large quantities of heat deposited there with each combustion cycle.

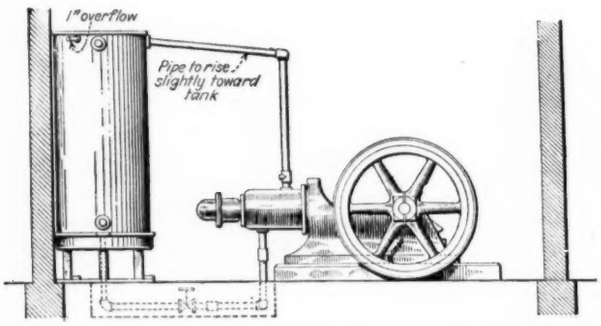


FIG. 1. THERMO-SIPHON WATER-COOLING SYSTEM

Both quality and quantity of water are important, as a hard water will deposit scale, while a scanty or interrupted flow will permit overheating of the metal walls. In either case heat strains will be set up and cracks are likely to occur, especially in complicated castings such as cylinder heads. There is no doubt that three-fourths of the fractures in properly designed cylinder heads are due to these causes.

It may be surprising to note how large an amount of heat is absorbed by the metal walls of the engine from the burning gases. Take a 65-hp. semi-Diesel oil engine for example. This engine at full load consumes 32 lb. of oil an hour, which at 19,000 B.t.u. a pound represents about 10,000 B.t.u. a minute. Of this quantity of heat about 30 per cent, or 3,000 B.t.u. a minute, is absorbed by the walls of the cylinder and head. The weight of metal in these walls exposed to the heat is about 350 lb., from which it may be calculated that if the walls were not cooled they would reach a red heat (900 deg. F.) in less than 12 minutes. The object of water-jacketing these walls is of course to remove the heat as fast as it is delivered and thus prevent the cracking and burning that would result from excessive temperatures. In fact, it is necessary to keep the cylinder walls much cooler than 900 deg. if the lubrication of the piston is to be accomplished, and also to permit the piston to give up its heat to the cylinder walls. The results of overheating are disastrous, and this can be prevented only by adequate cooling of the engine jackets.

To assure a vigorous flow of water through all the jacket and to prevent the formation of vapor pockets, there should be circulated 7 or 8 gallons per hour per horsepower. With a modern high-efficiency engine this will result in a temperature rise of about 40 deg. F. in the engine jackets.

While an ample supply of cooling water is of prime importance, consideration must also be given to the fact that in some places soft clean water is expensive. Under such circumstances it costs too much to run the water to waste after passing through the engine, and a more highly developed system is advisable by means of which the same initial stock of water may be used over and over again with little or no loss.

Quality of the Water

Not only must the supply of water be adequate to remove the heat rapidly from the cylinder walls, but the water must not contain much impurities either in solution or in suspension. If it does, the water jackets will soon become clogged with scale or mud, the effects of which are just as harmful in an oil-engine water jacket as in the water space of a steam boiler. However, there is this difference: In a steam boiler, scale will form from the sulphates and carbonates of calcium and magnesium held in solution, while in an engine water jacket, where the temperature never exceeds the boiling point (212 deg. F.), only the carbonates are precipitated as scale when the water is heated. In other words, a certain water containing a considerable quantity of sulphates but not carbonates might have a bad record as a boiler water, but would be satisfactory for cooling an engine. However, such cases are comparatively rare, as waters containing any mineral salts in solution are seldom free from carbonates. Water containing more than 6 grains per gallon of calcium and magnesium carbonates should not be used in engine jackets.

Carbonates are held in solution by an excess of carbon-dioxide gas in the water. When this gas is driven off by heat, the carbonates are precipitated in the form of a hard white scale which adheres firmly to the walls of the jacket and forms a non-conducting coating which retards the transmission of heat from the metal walls to the water. The consequence is that the metal walls attain an abnormally high temperature, causing inequalities in expansion and, when the scale is thick enough, finally resulting in excessive stresses which cause the casting to crack.

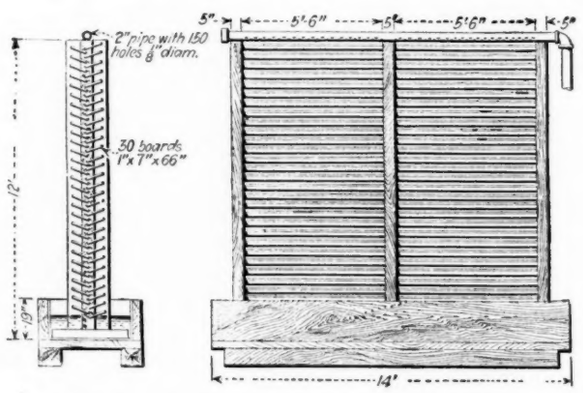


FIG. 2. TYPICAL WATER-COOLING TOWER

Originally, water recooling systems were designed merely for the purpose of saving water where it was scarce or expensive. More recently, however, such systems are being used, even though hard or dirty water is abundant, in order to supply engines with soft clean water.

Use of Cooling Tanks

The first step in trying to save water was to use large cooling tanks through which the water was circulated by the thermo-siphon system, where the difference in weight between the column of cold water and the column of hot water produced a continuous but slow movement of the water. A typical arrangement of this kind is shown in Fig. 1. It will be noted that the cooling is done almost entirely by radiation from the shells of the tanks and by evaporation from the water surfaces within them. Consequently, large tanks have to be used. Such systems are better adapted to small engines than to large ones, as in the latter case the system becomes quite unwieldy owing to the very large tank

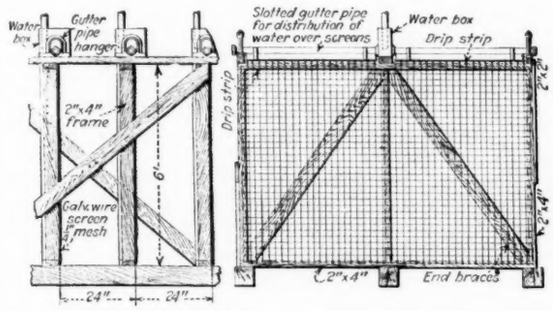


FIG. 3. DESIGN OF SCREEN-TYPE COOLING TOWER

capacity required. A 50-hp. engine requires three tanks 4 ft. 4 in. in diameter and 8 ft. high, but if operation is continuous under heavy load for more than 10 hours a day even this is not sufficient and the engine cannot be successfully cooled in this way. Furthermore, the thermo-siphon circulation is not entirely reliable, as it may be stopped by a partial obstruction in the piping. Thermo-siphon systems are rarely used in modern installations of more than 25 horsepower.

Open Cooling Systems

The next development was the use of cooling towers to afford greater cooling effect than was possible with tanks. Such cooling towers are frequently described as "open" cooling systems because the water is exposed to the air. They were first made of wooden boards, a number of strips being arranged vertically one above another in such a manner that the hot water from the engine after being delivered at the top of the tower would trickle over the wood surfaces and fall through the air from each strip to the next lower one until it reached the receiving pan at the bottom. A typical wood cooling tower is shown in Fig. 2. The cooling of the water is effected through direct contact with air and also by evaporation, the latter process doing a larger proportion of the cooling when the air temperature is not much below the water temperature.

To evaporate a pound of water at atmospheric pressure requires 970 B.t.u., whereas to cool a pound of water 1 deg. requires only 1 B.t.u. Inasmuch as the heat units to evaporate the water on a cooling tower must come largely from the remainder of the water which is not evaporated, it is clear that by allowing one pound of water to evaporate, about 25 remaining pounds of water will be cooled 40 deg. or in other words the evaporation of about 4 per cent of the water passed over the tower will cool the remainder through a sufficient range of temperature to permit its use again in the engine.

A little later a more efficient type of open cooling system was developed, consisting of a vertical wood or metal frame with wire screen about ½ in. mesh, stretched on it. Such a screen-type cooling tower is shown in Fig. 3. The hot water from the engine is delivered at the tops of the screens and trickles down over the wire mesh in a thin film. Being exposed to the air on both sides of this film, cooling is rapidly effected by direct contact with the air and by evaporation. These screen-type cooling towers are much more compact and efficient than the wooden towers, but more subject to deterioration through corrosion and rust. However, the screens can be quickly and cheaply replaced and such towers have been used for a long time. In a temperate climate two screens 6 ft. high by 9 ft. long will cool a 100-hp. modern-type engine.

Faults of Open Cooling Systems

The cooling towers, or open cooling systems, just described, have unfortunately two serious faults. In the first place there is a considerable loss of water, through evaporation and wind, and in arid climates where water is scarce, sufficient makeup water is often hard to obtain at a reasonable cost. The loss is usually from 4 to 10 per cent of the water passed over the cooling tower. Many oil engines are installed in arid districts in Arizona, Kansas, Oklahoma, etc., where this quantity of makeup water can be obtained only at prohibitive cost.

The second serious fault of open cooling systems is the fact that they concentrate the impurities in the water. If the water is hard, scale will be formed in the engine water-jackets the same as in a simple cooling system where the water is discharged to waste. But in the open cooling system, even with water only slightly hard, concentration of the mineral salts in solution occurs rapidly, so that a water originally safe soon becomes loaded with scale-forming constituents and deposits a coating of scale in the engine water jackets. This concentration of impurities occurs because the evaporation at the cooling tower consists of pure water only and the materials originally dissolved in the evaporated water remain behind, dissolved in the rest of the water. With new makeup water mineral constituents are added to the system, which thus becomes more and more impure, resulting in scale deposits in the water-jackets. The same process of concentration of impurities occurs in a steam boiler and necessitates blowing down occasionally to get rid of the impure water.

Because of these two serious faults of open cooling systems—expense of makeup water and danger of scale—the modern inclosed cooling systems were developed.

Overhead Supply Tank

While these open cooling systems were being installed, the importance of using overhead supply tanks was learned. In the past engines had often been supplied with water direct from the discharge of a small pump. If the pump failed for any reason, such as loss of suction, slipping off of the belt, etc., the water supply would immediately cease and if the engine were not

stopped at once it would become overheated, resulting in serious damage. Furthermore, if the circulating pump was driven directly from the engine, as was frequently the case, the engine would not receive an ample supply of water until some time after being started up. If the water-jackets had been drained overnight to prevent freezing or if there had been leakage from the piping, this would result in the engine being started with empty water-jackets, which is of course an unwise procedure.

It must not be thought that the necessity of taking these precautions denotes a delicate or sensitive type of machinery. An oil engine is entitled to receive ordinary operating care like any kind of power-plant equipment, and no one should undertake to start up an engine without water, any more than he would want to fire up an empty steam boiler or with the boiler-feed pump out of commission. It was found by experience that the only safe way to cool an engine, unless the water came from city water mains not subject to interruption, was to have a large overhead storage tank from which the engine received its water by means of gravity. This tank should be large enough to supply the engine for at least a half hour in case of breakdown of the circulating pump. For example, a modern high-efficiency engine of 100 hp. would require a tank capacity of at least 400 gal. The tank should be provided with a water-level indicator, and if there is any danger of the water running low without the engineer knowing of it, a low-water alarm should also be installed. The circulating pump should have a larger capacity than the maximum requirements of the engine so that it will always keep the overhead tank full and overflowing. For a 100-hp. unit the pump capacity should be 20 gal. per min. The quantity of water supplied to the engine should be adjusted by a valve in the engine supply line and not by regulating the capacity of the pump, which should be constant.

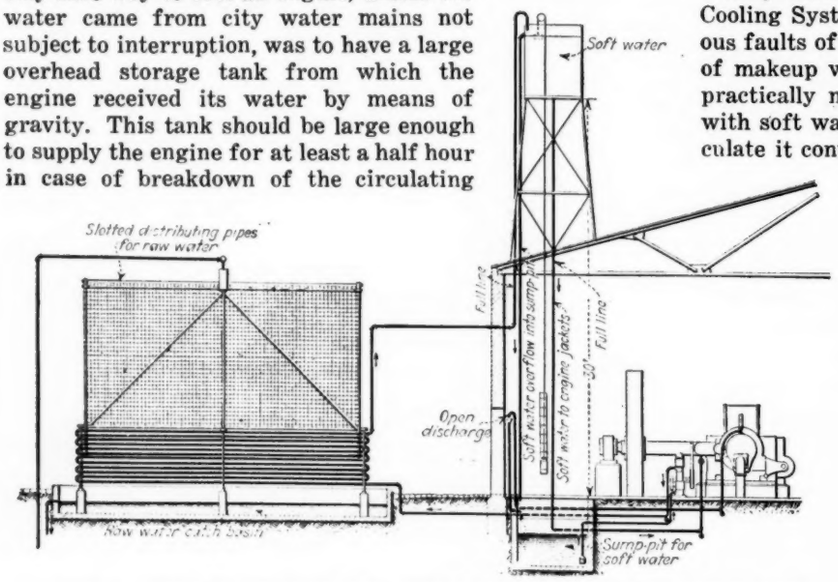


FIG. 4. DESIGN OF INCLOSED COOLING SYSTEM WITH RECOOLING SCREENS FOR RAW WATER

If the water is to be saved and re-used, a sump should be used which is large enough to receive the entire contents of the overhead tank. Then, even if the circulating pump fails, the overhead tank will supply the engine for a half hour and the discharge water will be retained in the sump, ready for use when the pump is started up again. A sump capacity of at least 500 gal. is recommended for a 100-hp. engine.

Another necessary feature of a correct water system was found to be the free discharge of the warm water from the engine jackets into a funnel or other open outlet in plain view of the engine operator. Any interruption of the water supply is then quickly indicated to the operator by the appearance of vapor at the water outlet. This is a much more effective indicator than a thermometer in the water outlet, as a high thermometer reading may not be noticed, whereas a cloud of steam cannot be overlooked. Another advantage of the visible discharge is that it shows the quantity of water flowing at each moment, and thus a sudden shortage of water may be discovered and remedied even before it has raised the engine-jacket temperature high enough to be noticed on a thermometer or other temperature-indicating device.

Inclosed Cooling Systems

The modern cooling system, which takes advantage of all the experience gained from the developments previously described, goes under the name of Inclosed Cooling System. This type overcomes the two serious faults of open cooling systems; namely, expense of makeup water and danger of scale. It requires practically no makeup water and, when once filled with soft water which cannot form scale, will recirculate it continuously for a long period.

The principal feature is that the jacket water is recooled in pipe coils over which other inferior water is showered. The only place where the engine water is exposed is at the visible outlet. The loss is therefore negligible and a sufficient amount of good makeup water (rain water, for example) can almost always be easily obtained. Any quantity of water may be showered over the outside of the cooling coils.

A typical inclosed cooling system is shown in Fig. 4. This system is filled at the start with soft water. The warm water from the engine outlet is discharged into a funnel on the engine-room wall, from which the water runs into a sump pit. From this pit a circulating pump delivers the water into the cooling coils (usually outside the building) and thence up into the overhead tank from which the engine is supplied by gravity.

The only place where the engine water is exposed is at the visible outlet over the funnel, and therefore little, if any, water is lost.

The raw water for cooling the pipe coils, if available in large quantities, may be distributed over the coils by means of a slotted gutter pipe in the same manner as an atmospheric ammonia condenser in a refrigerating system. With this arrangement a cooling coil made of twelve 2-in. pipes 20 ft. long is adequate for a 100-hp. modern-type oil engine. For an engine of this size the raw-water supply should be 25 gal. per min. The capacity of the overhead storage tank, the sump pit and the soft-water circulating pump should be the same as for the open cooling systems previously described.

Where there is a scarcity even of inferior water for showering over the outside of the pipe coils the inclosed cooling system as arranged in Fig. 4 may be used. The raw water itself is caught in a basin below the pipes and pumped by a second pump over an open screen-type cooling tower, where it is recooled and then

used again over the pipe coils. The logical location for the wire screens is over the pipe coils themselves, so that the cooled raw water as it drops off the bottom of the screens falls directly on the top pipes of the cooling coils. To secure the best results, the pipe coils are made lower than in the ordinary case previously described, and for a 100-hp. engine are recommended two coils each made of six 2-in. pipes 20 ft. long. Over each coil is mounted a ¼-in. mesh wire screen 6 ft. high and 20 ft. long.

The system just described may seem elaborate and complicated, but in reality it is not so and it can be operated with great ease. Where the water available is of inferior character and besides is extremely scarce, as in the mining regions of western Texas, such systems afford the only satisfactory method known of cooling internal-combustion engines, and several installations have been in use for a number of years with entire success. One oil pipe-line company has equipped all its plants with similar systems.

The important feature of these inclosed cooling systems is that nothing but good soft water ever passes into the engine jackets.

Reciprocating pumps are much to be preferred to centrifugal pumps for water-circulating systems. Centrifugal pumps are subject to irregularity in action when the operating conditions change from normal. For example, when the discharge head is increased through an obstruction in the piping, the quantity of water delivered by the centrifugal pump will greatly decrease. Furthermore, centrifugal pumps, when lifting warm water from the sump, are more liable to become vapor-bound and stop delivering entirely. Reciprocating pumps, though more expensive, are more positive and reliable, and this is a most important feature of any engine jacket-water system. Centrifugal pumps should be used only in the simplest systems, circulating cool water which is received at the pump under a gravity head and discharged against a definite and constant pressure.

Something About Steam Pumps

By W. H. WAKEMAN

A STEAM pump is usually a rugged machine, designed to run under crude conditions with just care enough to prevent it from total failure, and built for hard and continuous service. There are times, however, when expert attention is required in order to insure smooth and satisfactory operation with intelligent care to prevent interruption of the service.

It is possible for the four strokes of a duplex pump to be alike, while one of the valves or one of the pistons is leaking. The leak may be detected by the sound of water rushing through the opening, but I have not found a sure way of determining where the leak may be, except to take the pump apart and examine the piston and valves.

One may happen to locate such troubles by observing the operation of pumps, but there is no infallible rule for this purpose. For illustration, in one of my plants there was a fire pump that was fitted with 40 valves. It drew water from a large cistern. When testing this pump one day, one of the pistons made one normal stroke and one quick stroke. Listening carefully, water could be heard as it rushed back through one of the suction ports. By removing a handhole cover in this part of the suction chamber, a stone about one-half inch in diameter was found under one of the suction valves. When this was removed, the pump made its proper strokes.

In another instance a pump took hot water from a receiver and it would make one stroke quicker than the other three. It was decided that something was the matter with one of the suction valves. An examination showed that a piece of wood prevented it from seating properly. It must have been left in the heating pipes by a careless steamfitter, and was finally carried into the pump.

At another time the same pump acted in much the same manner, but an examination of the suction valves showed them to be in good order. This pump would make one normal stroke and one rapid one, on one side, and during the latter stroke water could be heard rushing through a small opening somewhere on the inside. Worn-out packing rings on the water piston proved to be the cause of the trouble.

Why did not the piston leak on both strokes? It would seem that the piston would leak on both strokes, but I have not always found it so in practice. The packing evidently takes a position that closes the leak on one stroke and opens it on the other. Of course this would not apply to outside-packed plunger pumps, or to piston pumps fitted with brass packing rings.

Another pump that is supplied with hot water from a receiver, would run fast and deliver water against a light pressure. When the water was turned into the boiler, the pump would continue to run fast, but little or no water would go against boiler pressure. The water pistons were in good condition, and there was nothing under any of the valves to hold them open. They were made of hard rubber, and long service had caused more or less wear. Some sheet packing ⅛ in. thick was cut into circular pieces about ¼ in. larger than the pump valves. A hole was cut in the center of each large enough to admit the valve stem, and one of them was put under each valve. This stopped all leakage at this point and rendered good service until there was time to restore true surfaces to the valves.

A certain engineer attempted to do the same thing, but failed because he used large tacks to fasten the packing to the valves. The heads rested on the brass seats, causing leaks and injuring the seats. Water being forced upward through the ports will lift circular pieces of packing, forcing them against the valves, and when the piston completes a stroke, pressure in the water box will force them down, thus showing that no tacks are required. Of course, such a makeshift is not recommended for permanent service, but it may prevent a considerable loss by permitting a pump to run a few days until permanent repairs can be made.

When hard- or soft-rubber valves become worn badly through long service, they may be refaced without being put in a lathe, as follows: Take a sheet of coarse sandpaper and tack it on a smooth board. Move the valve briskly over the surface until the high spots are all worn

down. Do not hold the valve in one position all through the process, but give it, say, half a dozen strokes, then turn it slightly and repeat the process until it has been given a complete revolution, which will prevent uneven cutting of the valve and give a satisfactory surface. This is not recommended for brass valves, but is practical for rubber.

If the seats are badly worn, it will pay to buy a machine that will act as a circular planer and restore them to condition, as a pump may lose much water on account of rough and uneven valve seats and still continue to operate without making uneven strokes or causing other trouble. However, it will run faster than if in order.

Some pumps are fitted with a device for setting out and tightening the fibrous packing in the water pistons. This is an excellent feature, but if it is set out too tight, it will cause excessive friction in the cylinder and shorten the stroke, thus reducing the capacity of the pump. If left too loose, it may cause one or both of the steam pistons to strike the heads because some of the water will slip past the pistons instead of being forced out through the discharge pipe, thus relieving the piston from some of its legitimate load.

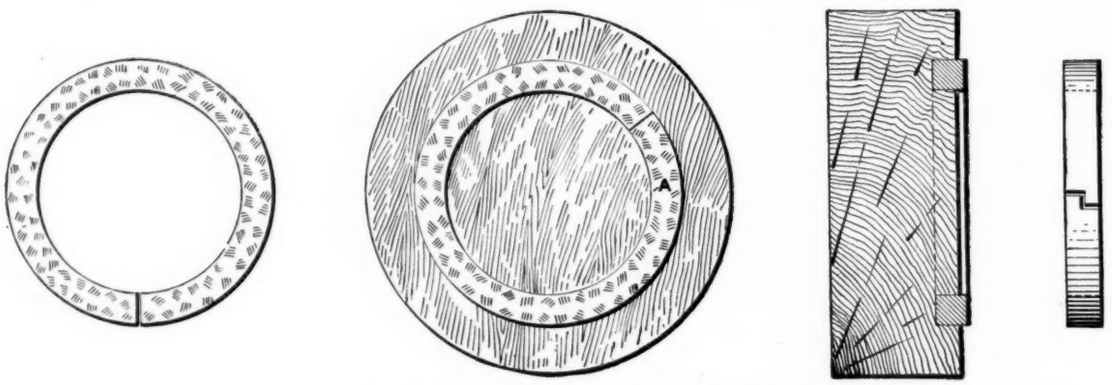
Having discovered that a certain pump manufacturer who formerly supplied these devices with his pumps, had discontinued the practice except on special order, he was asked for the reason. His reply was that engineers could not, or would not, learn how to use them properly, thus causing more or less dissatisfaction, hence they supply a solid piston that could not be adjusted.

When a pump is fitted with one steam and one water cylinder, it is a single pump, but it is not single acting, although men sometimes give it that name. A pump that discharges water on both strokes is a double-acting pump regardless of the number of cylinders. Nearly all belt-driven or power pumps are single-acting because they only draw in water on the upward stroke and discharge it when the piston comes down. This refers to vertical pumps, but many of the horizontal power pumps are double-acting.

A simple pump uses steam in one cylinder and then discharges it to the atmosphere or to some kind of a heating system. This is in contrast to a compound pump, which uses steam in one cylinder and then discharges into another which is much larger than the first. After it is utilized in this one, it goes out to be wasted or used according to conditions, but to allow it to be discharged directly into the outer air and then use live steam for heating purposes is a waste of fuel.

A duplex pump has two steam and two water cylinders and both of them are double-acting. It possesses two advantages over a single pump, as it delivers a nearly continuous stream of water and is more positive in action. However, a duplex pump is not suitable for lifting water from a well or stream where the surface is 25 ft. below the pump, therefore a single pump should be adopted for this service.

If water flows to a pump, there may be a slight leak at the piston-rod stuffing box which does no harm, but assists in lubricating the rod, but for high lifts there must be no leakage if good service is wanted. On this account care must be taken to provide suitable packing for the rods. Several kinds are available that are well lubricated with graphite. They are soft and pliable when new and do not become hard when used for a reasonable time. Such packing rings have been taken out of a stuffing box and being found still pliable, they were turned so that the outer surface was brought into contact with the rod and they were then good for several months' use. If fresh graphite is put on the wearing surface, it will be beneficial. Some kinds of packing rings are not very soft when new, hence they should be thrown away before becoming hard enough to score the rod. Neglect of this precaution has ruined many good pump rods, especially if made of brass. Such rods are more expensive than steel rods and are entitled to better care, but they do not always receive it.



WAYS OF CUTTING PACKING FOR PACKING PUMP PLUNGERS

When a pump is fitted with solid brass pistons, the engineer has no choice in the matter, but must use them even if he knows they are leaking more or less, until they leak excessively, then they can be taken out and new ones put in. If the pistons are designed to be renewed by means of fibrous packing, they can be replaced at pleasure, thus lasting indefinitely.

To pack a piston is not a difficult job, but there is a right and a wrong way to do it. A certain engineer packed the piston of a hot-water pump, and when he attempted to pump water it would not go. The trouble was caused by taking dry packing and making a tight joint, as shown at the left of the illustration. When soaked in hot water, it swelled until it was held fast in the cylinder. He took it out, cut $\frac{1}{8}$ in. from one end, replaced it and had no more trouble. One way to avoid this trouble is to soak the packing in hot water before it is fitted to the cylinder. Another way is to buy packing that is not affected by hot water.

Pumps are frequently located where it is not practical to look into the water cylinders while inserting the packing, hence it is convenient to have a wooden form

for each size of pump, as shown in the two center views. The groove *A* is just the right size to receive the packing, hence when it is nicely fitted into this groove it is formed into a true circle, and of the right diameter for the cylinder for which it is intended.

When a plain joint is made by cutting the packing square across, an allowance must be made for expansion if hot water is to be used, but just how much it is impossible to state. Perhaps $\frac{1}{8}$ in. will be sufficient. If a step joint is made, as shown at the right in the illustration, it prevents any open space from appearing at this point, even if the ring is a trifle small so that the ends are drawn away from each other as the ring is spread to fit the cylinder.

Of course it is possible to buy these rings all ready to put into the water cylinder, but they cost more, and rings must be carried in stock to fit each pump of a different size, whereas by carrying rolls of packing in stock, rings of any diameter can be cut at pleasure. Solid rings can be bought that are cut to any size required; if they are preferred, but care must be taken to order just what is wanted, as they cannot be adjusted like those just illustrated, for obvious reasons.

Pump makers sometimes pack a 4-in. pump with $\frac{3}{8}$-in. packing, put $\frac{1}{2}$-in. packing into a 5-in. and use $\frac{3}{4}$-in. packing on a 7-in. cylinder, but that is not necessary as the larger size mentioned can be packed with $\frac{3}{8}$-in. packing, and it will give just as good service as the larger style. The cost will be much less and the smaller kind is more pliable and convenient.

American Flue Cleaner

An examination of Fig. 1 will show that the cleaning element on the American flue cleaner is attached to the smoke-chamber doors of the boiler and swings outwardly with them when it is necessary to work on

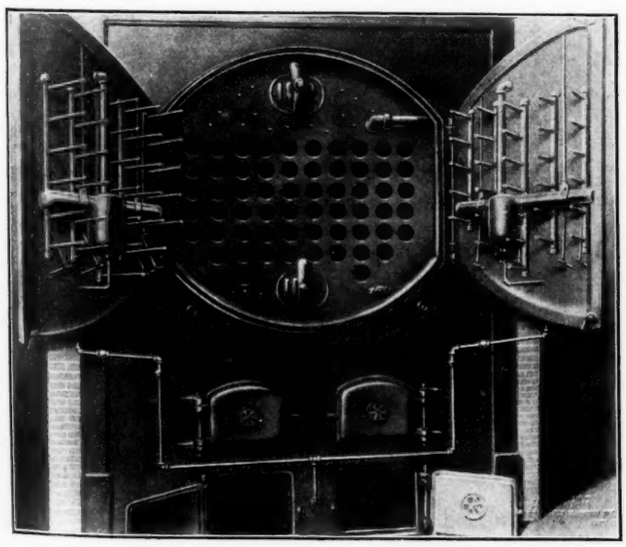


FIG. 1. CLEANER NOZZLE OF TUBE BLOWER

the boiler tubes, after breaking connections. Each row of tubes is handled independently, having a valve, Fig. 2, which is part of the cleaner and is made fast to the header. As each tube has a steam jet, the work of blowing the soot is continuous and all the tubes are blown at the same time.

When steam is turned on to put the tube cleaner in operation, the operator pushes the stems of the automatic drip valves and the steam pressure from the separator holds them shut. The disc of each automatic drip valve has a hole in it for draining the system, but these holes are so small that there is little discharge of steam during the cleaning operation, thus assuring

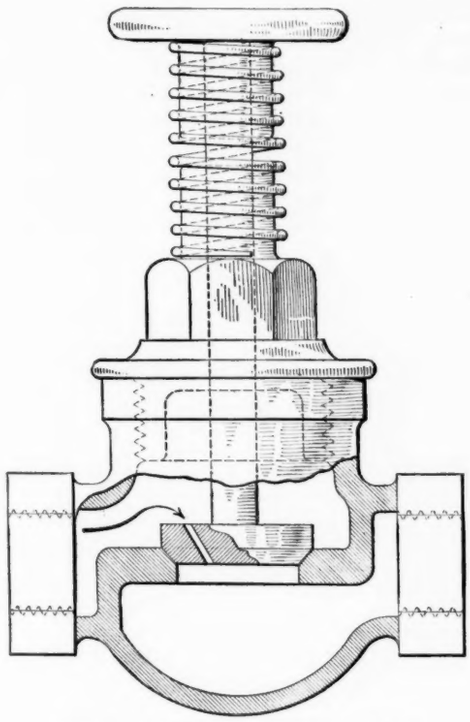


FIG. 2. AUTOMATIC DRIP VALVE

dry steam to the tubes. Due to the drip valves, condensation is prevented from being blown into the tubes when putting the cleaner into operation, and when the operation of cleaning is over, the drip valves automatically open for the next operation.

When it is desired to clean a tube, open the main steam valve, which is on the front of the boiler setting, by a pull chain. As soon as the valve is open, the steam flows to the separators and any entrained moisture will pass out through the automatic drip valves to the ashpit. The fireman can blow each vertical row of tubes separately by pulling out one of the knobbed handles which controls a valve, operating one handle after the other until all the tubes are blown. The operation of cleaning the tubes can be carried on while the blower is under normal steaming. This cleaner is manufactured by the American Flue Cleaner Co., 1826-28 E. Willard St., Philadelphia, Pa.

A new census of developed water power in the United States is being made under the direction of A. H. Horton, of the United States Geological Survey. It is planned to complete the census by Jan. 1. Mr. Horton is a native of Franklin, Pa., and has been in the Government service ever since his graduation from Cornell University in 1898. He joined the Geological Survey in 1906, and it was under his direction that the state maps showing the location of power stations and transmission lines used in the public service were prepared.

Reversing Direct-Current Motors

By EUSTIS H. THOMPSON

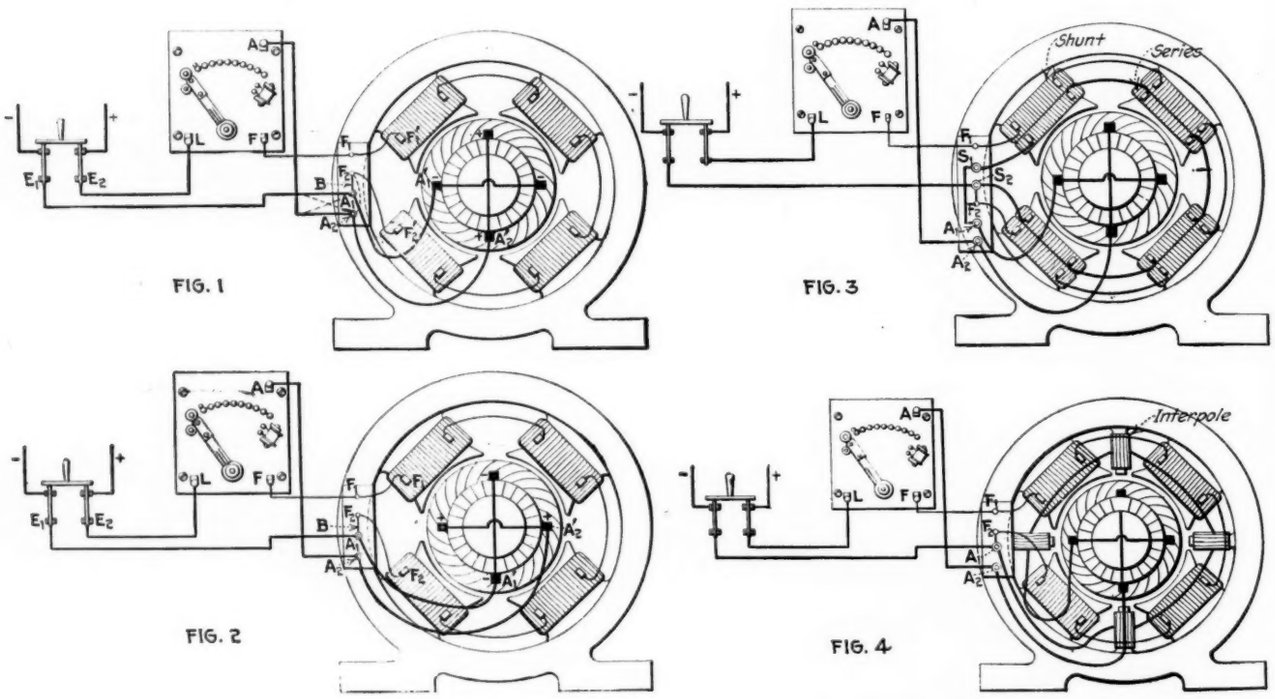
IN A large percentage of applications motors rotate in one direction only. The only time they are reversed is when they are first put into service if, when as first wired up, they happen to run in the wrong direction. However, it frequently occurs that a motor is changed from one location to another or, as a spare unit is connected up temporarily, and it becomes necessary to change connections to reverse the direction of rotation. The rules covering such changes are not difficult to understand, but may at first appear complicated to the uninitiated.

To reverse the rotation of a shunt motor, reverse the direction of either (1) field current or (2) armature current. Reversing both will not change the direction of rotation. (3) Shift the brushes one pole space; that is, shift them from one neutral point to the next. Fig. 1 shows a direct-current shunt motor connected to a manual-type starting box. The field current may be reversed by: (1) Interchanging the leads at the terminals F'_1 and F'_2 of the field windings; (2) at the ends of the field leads F' and F_2. The armature current may be reversed by: (1) Reversing the leads at the brush terminals A'_1 and A'_2; (2) reversing the leads at the outside terminals A_1 and A_2; (3) by shifting the brush yoke one polar interval, then the neutral point on the commutator that was previously in contact with the positive brush is now in contact with the negative brush, as will be seen by comparing Fig. 1 with Fig. 2. Shifting the brushes has the effect of reversing the current in the armature, just as either of the two preceding changes has. This procedure is not convenient where the connections to the brush rigging are too heavy or stiff to allow this movement of the yoke, and is not desirable on two-pole machines where it places the leads in an awkward position.

If the main leads at E_1 and E_2 are interchanged, the motor will not reverse, because both the field current and the armature current are reversed at the same time and this will produce the same rotation as before.

When the main leads outside of the machine are reversed at A_1 and A_2, as indicated by the dotted lines, the field wire B should be brought over to terminal A_2 as shown by the dotted line, in order to place the shunt field across the line, otherwise the two field terminals will be connected to the same side of the line and the motor will not operate satisfactorily. This is a mistake that is often made in connecting up motors. The wire running from the armature connection A_1 and the field connection F_2 on the motor is connected to the A terminal on the starter, and the armature connection A_2 on the motor is taken to the switch. Under such conditions there is no field on the motor except at starting, when the shunt-field winding is thrown in multiple with the starting resistance. When the starting resistance is cut out, the field is reduced to zero, and if the motor is running light it will race and may destroy the armature windings by centrifugal force. If the motor should be connected to a heavy load, it will blow the fuses instead of racing. Motors have been wrecked by making this mistake in connecting up, therefore the wiring should be carefully traced.

The connections can easily be tested in addition to



FIGS. 1 TO 4. CONNECTION DIAGRAMS FOR SHUNT AND COMPOUND MOTORS

Fig. 1.—Connection diagram for shunt motor. Fig. 2.—Same as Fig. 1 with brushes shifted one pole space to reverse direction of rotation. Fig. 3.—Connection diagram for compound-wound motor. Fig. 4.—Connection diagram for shunt-interpole motor.

tracing out the wiring. Open the armature circuit by disconnecting the wire from the *A* terminal on the starting box. Bring the handle of the rheostat to the running position. If the field is connected right, there are three indications: (1) The magnet will hold the handle in running position; (2) the field poles will show strong magnetism if touched with a piece of iron; (3) on opening the main switch, a long, thin arc will be produced due to the field current. If a field is absent, all these tests should be negative.

When the rotation of the machine is changed, in which the brushes are shifted away from the neutral

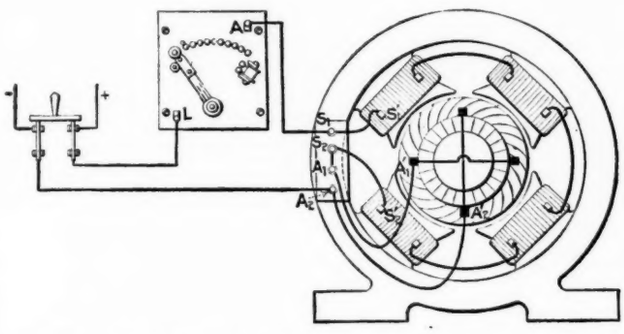


FIG. 5. CONNECTION DIAGRAM FOR SERIES MOTOR

point, the brushes should be shifted to the other side of the neutral point by the same amount in order to obtain proper commutation. The neutral points are the commutator bars that are connected to the armature coils located midway between the main polepieces. In most armatures the neutral bars are exactly on the center line of the main field poles. In some types of armatures the neutral bars are midway between the field poles; this depends on the manner of connecting the bars to the armature coils.

Motors that are used for reversing duty usually are equipped with brushes that are set radially with the commutator, while machines that are run in one direction only are often equipped with brushes that are set at an angle to the diameter of the commutator. In the latter case it may be necessary to have the same relation to the new rotation that the brushes had to the original rotation. If the commutator runs against the heel of the brushes originally, the brushes should be changed so that the commutator runs from heel to toe in the new rotation. This involves a change of the brush-holder on the studs. When making such reversal, be sure that the same angle to the commutator is obtained as formerly existed. Check the position of the brushes carefully after reversing to make sure that they are still in the same position on the commutator. This will generally require shifting the brush yoke back a number of segments against the direction of rotation.

When reversing a compound motor, the series field should be reversed when the shunt field is reversed. The series field should not be reversed when the armature leads are reversed or if the brushes are shifted a pole. Fig. 3 shows the general connections of a compound motor to a manual-type starting box. Generally, the most convenient way to reverse a compound motor is to interchange the armature connections; that is, interchange the connections on terminals A_1 and A_2, Fig. 3. This obviates any possibility of mixing up the field connections. Where it can be conveniently done, shifting the brushes is the preferred method, since none of the connections is interfered with.

When reversing an interpole motor, if the armature current is reversed the current in the interpole field winding should be reversed. One terminal of the interpole winding usually connects directly to the brushes as in Fig. 4, so that to reverse the motor all that is necessary is to interchange the connections or terminals A_1 and A_2. The motor can also be reversed by interchanging the shunt-field connections as explained for Fig. 1. The interpole field or compensating winding should not be reversed when the shunt field is reversed or when a compound motor is reversed by reversing the current through the shunt- and series-field windings. Should the machine be reversed by shifting the brushes, then the interpole winding will also have to be reversed; for this reason it is well to avoid shifting the brushes on an interpole machine.

A series motor like the shunt machine may have its rotation reversed by changing the direction of the current through the armature or through the field winding. Fig. 5 shows the connections of a series motor. The field current may be reversed: (1) By reversing the leads on the terminals of the field windings S'_1 and S'_2; (2) by reversing the leads outside of the machine at S_1 and S_2. The armature may be reversed: (1) By reversing the leads at the brushes A'_1 and A'_2; (2) by reversing the leads outside the machine at A_1 and A_2; (3) by shifting the brushes one polar space, as for the shunt machine. In case an interpole field is present, this field and armature are reversed together the same as for a shunt motor. If an interpole field or compensating winding is present, it should not be reversed when the series field is reversed. If the armature is reversed by shifting the brushes, then the interpole field must also be reversed.

The Design of an Internally Fired Superheater

BY W. R. WOOLRICH*

Nearly one century has passed since the first application of superheat to steam engines. A search of our industrial histories would indicate that Richard Trevithick and Captain Gregor, of Cornwall, England, in 1818, were the first engineers to use superheated steam. These men, in an attempt to rival the performance of an engine in a near-by mine where the cylinder had been lagged in sawdust, surrounded their cylinder and steam pipes with a coal-fired furnace. The results were far better than anticipated and a new record was established.

In America the installation of superheaters on locomotives probably has given the practice its greatest impetus. The high velocity of the burned gases within a locomotive assists in keeping the soot deposit on the superheater tubes at a minimum and also insures a high degree of superheat. Thus the conditions within the locomotive are very satisfactory for superheater performance. In stationary practice such high velocities do not exist, and consequently large deposits of soot are common on the boiler tubes. This condition, combined with the relatively low conductivity of superheated or saturated steam as compared with water, has made advisable the installation of the superheating sur-

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face for coal-fired stationary boilers in the first pass through which the burned gases must travel.

The separately fired superheater has been adopted only for special conditions. In general, the economy is not satisfactory, and only under special conditions where the lack of economy can be counterbalanced by the advantages obtained, has the separately fired superheater a place.

As early as 1910 experiments were tried at the University of Tennessee to superheat steam by the combus-

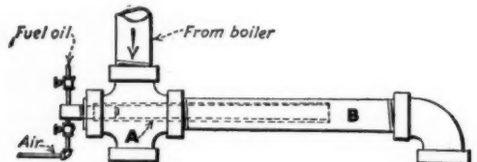


FIG. 1. ORIGINAL DESIGN OF SUPERHEATER BURNER

tion of gas, the burner to operate within the steam main against the steam main pressure. This experiment was inspired by a statement made by Prof. Unwin over a decade ago in which he stated that it might be possible to superheat steam by such an arrangement. While there is evidence that considerable preparation was made, there is no written record to indicate that positive results were obtained.

In 1916-17, a design was assembled by the writer. Fundamentally, the apparatus consisted of a commercial air-atomizing oil burner designed for high pressures, with its tip projecting into the steam pipe. The oil was furnished at a pressure equal to the air pressure plus a low static head, and the air pressure was maintained at from ten to twelve pounds greater than that of the steam.

In actual test when the burner was ignited and the steam line closed, it was found that no adjustment would give a suitable flame at the burner tip. The engine bleeder valves were kept open to maintain a pressure relief, but this did not solve the problem. Repeated attempts at adjustment gave no relief. As soon as the outside supply of air was shut off, the flame would go out. The writer had failed to appreciate that the commercial oil burner is designed to secure only a part of its air supply from the burners, relying on the surrounding air to make up the deficiency.

H. E. Ayres took up the problem in 1919 as an undergraduate thesis. After a survey of the burners on the market, it was decided that a new design was necessary. The burner finally made up was really a combination of two standard oxyacetylene welding torches with several added features. This burner was assembled as indicated in Fig. 1, *A* being the burner, *B* the steam main and *C* a removable plug. To simplify the problems as much as possible, it was decided to operate on commercial gas instead of oil. This would eliminate a considerable amount of carbureting difficulties.

This burner operated successfully with the steam main closed to the atmosphere. The ignition system was changed from the flame to the spark-plug type. Only on one test, however, was it possible to get the flame to continue to burn after the steam was admitted to the main. On this test a superheat of 25 deg. F. was recorded for a short time. It was evident that some progress had been made, but there still remained a host of difficulties to be overcome.

At graduation Mr. Ayres passed on the results of his work to O. A. Kraehenbuehk, who reassembled the apparatus as shown in Fig. 2. The results at first obtained were very unsatisfactory. No difficulty was experienced operating the burner in the closed main, but when the steam was turned on at any working pressure, the flame would be extinguished. After a series of tests and adjustments the burner suddenly started to operate. Its operation was very erratic at times, then suddenly it would start to burn steadily and would give a most interesting demonstration of its possibilities for probably an hour. It was very evident that the two factors that were greatly influencing the operation of the burner were the quality of the steam and the differential pressure between the air and gas supply and the steam main.

Over a period of several weeks further experiments were made with the apparatus. The information and results secured must be accepted for their value under varying conditions, and since new adjustments were continually being made, it is not the final effort on a large and interesting problem, but merely a report on a research in process. We are presenting them here through the technical press to encourage constructive suggestions and to place before engineers such information as we have available to date.

The solution of the first difficult problem has been proved possible; that is, that gas will burn in the presence of high-pressure steam. Our next great task is to refine the process down to the point that we know it will operate as a commercial certainty.

The application of this process of superheating to units operating condensing presents one of the extremely interesting problems involved. The byproducts not being condensible will have some effect upon the vacuum. Just how serious this is going to be in practice must be determined. The thermodynamics underlying this problem of mixtures is complex. Experiments are now under way to apply this method of superheating to exhaust steam to be used in dye tubs, laundries and similar commercial processes where steam temperatures over 212 deg. F. are required. In this field an internally fired superheater is especially adapted. The pressures are low, and the volume is too great to permit the use of separately fired superheaters. For an internally fired superheater the low pressure and large volume are ideal conditions.

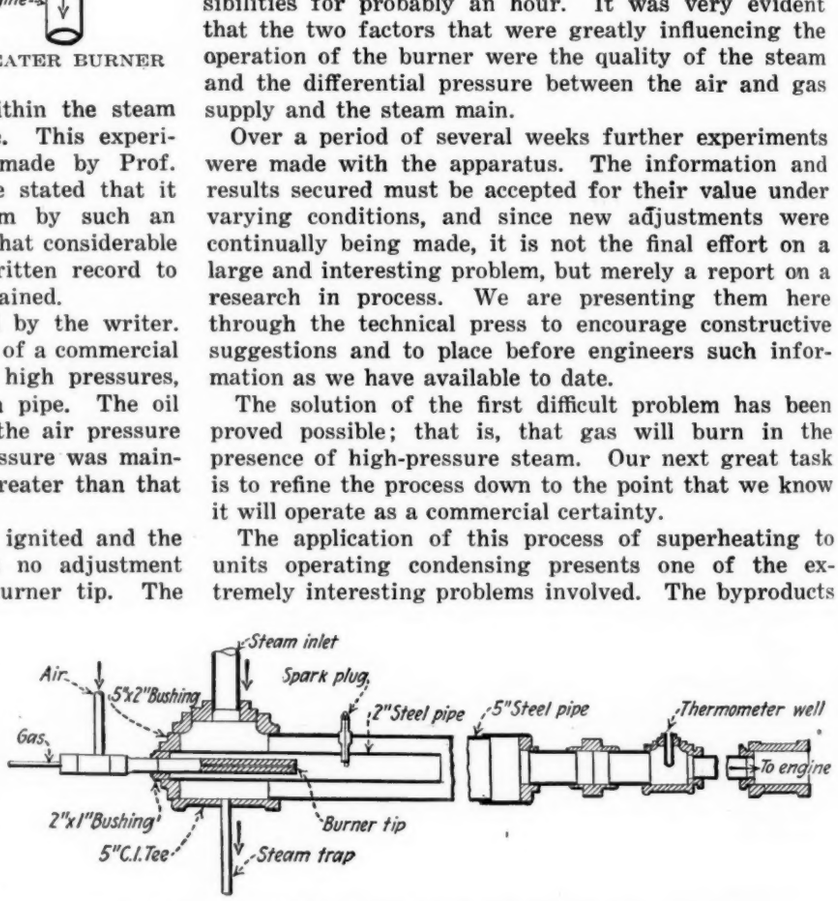


FIG. 2. MODIFIED DESIGN OF BURNER USING GAS AS FUEL

Power-Plant Accounts—IX. The Power Plant as a Manufacturing Department

By WILFRED A. MILLER

THE man who operates an isolated power station is in an unfortunate position when it comes to showing what his department is doing toward earning profits for the enterprise of which it is one of the units. The best example in illustration of the fact is the usual type of factory. Let it be assumed that we are dealing with one that has several departments, each turning out a different product. For instance, Department A turns out stamped metal parts. It is found that the total cost per piece is 20 cents. If we admit that 10 per cent is a fair profit to allow on the sale of this particular product, we find that the profit will be 2 cents, so that the price for which the part should sell is 22 cents. Just what it can be sold for is another matter. If competitors are selling the same thing for 21 cents, we must either meet their price or go without selling our product. On the other hand, there may be a scarcity of the product, in consequence of which our salesmen find that they can get 24 cents for the article. So it will be seen that the percentage of profit depends largely on what competitors are doing and the state of the market for the particular product we are interested in.

Over the state of the market we have no control, and we must therefore accept whatever changes in prices are caused by it and the consequent changes in our profits. But there is another factor in the situation that is under the control of the concern, and that is the cost of manufacture. If the superintendent of Department A can cut down his cost by one cent it will have much the same effect as raising the selling price by that much. It is therefore apparent that the superintendent of a manufacturing department has it within his power to materially influence the earnings of the concern by which he is engaged. It is likely that an incompetent or indifferent superintendent will not find means for cutting down costs. In fact, he will probably not even be capable of keeping them at a constant level, but will find them gradually rising in spite of himself. The management knows this, and therefore every superintendent is held strictly to account for the cost of the article that he is manufacturing. At the end of every month or at the end of a year figures are compiled showing how much each product has cost and how much it was estimated it should have cost. These reports are submitted to the superintendents, so that each one knows how much or how little he has contributed toward the welfare of the organization as a whole.

Very seldom, however, is this done for the man who runs the department that manufactures steam and power. Here is the big disadvantage under which the power-plant man labors. No matter how he strives to cut down his costs, no matter how well he succeeds, it is only too seldom that any recognition of the facts is accorded him.

This unsatisfactory condition of things may be overcome by looking upon the power plant as an independent factory engaged in the manufacture of power, which it sells to the various departments of the mill as if they were outside customers. Each of these departments might in turn be treated as a separate manufacturing establishment, it merely remaining to combine the results of all these little separate factories at the end of each month to find out what the result for all of them combined shows. Let us consider our bookkeeping from this point of view and see where it leads us.

This is the ninth of a series of articles written in conversational style and treating the subject of power-plant accounts in a thorough, yet simple manner. They were prepared primarily for the guidance of the operating engineer who wishes to keep track of the cost of the power he is making, but who knows nothing at all about bookkeeping. Others may find the articles helpful in clearing up their ideas on the subject. This installment shows how the power plant may be put on the same basis as any other manufacturing department. Careful consideration is given to the departmental "profit" that may properly be allowed the power plant and to the significance of this profit from the viewpoint of the business as a whole.

To begin with, if we are to consider ourselves as a separate manufacturing organization, we must insist on making a profit on what we sell. The question then arises, What do we sell? The answer may be steam, or it may be mechanical power, or it may be electrical power, or it may be any combination of these or all of them. For the purpose of simplicity in our present discussion we will make the assumption that the only thing we sell is electricity. Electrical energy is the simplest of them all to measure accurately, and therefore lends itself best to the purposes of our study.

Assume, therefore, that we are generating electricity for distribution to the various manufacturing departments and that we have a watt-hour meter in the feeder to each of these departments, so that we can keep track of how much energy each one of them uses. This we can, of course, do very readily by taking a reading of each meter on the first day of each month and making a record of it in some kind of a log, preferably in a memorandum book kept for the purpose. This may be arranged as shown in the figure. In addition to the feeder meters we should have a watt-hour meter on each generating unit so that we can tell how much power we have generated altogether. This amount will always be greater than the total supplied to the various departments because we use electricity in the power house itself for various purposes, such as motor drives, lighting and so on. In order to get a true cost per kilowatt-hour, we ought to divide the total expenses by the total number of kilowatt-hours, including the current used in the power house itself, and then charge ourselves with the amount of current that we have used.

However, such a treatment would complicate our calculations unduly for the purpose we have in mind, and we shall therefore satisfy ourselves with a rate per kilowatt-hour obtained by dividing the total kilowatt-hours supplied to the various manufacturing departments during a month into our total costs for the month. For example, we find the following to be the conditions for the month of September, 1920:

Department A used 30,000 kw.-hr.
Department B used 25,000 kw.-hr.
Department C used 20,000 kw.-hr.
Department D used 125,000 kw.-hr.

Total power 200,000 kw.-hr.
Total cost of producing power, $3,600

The cost per kilowatt-hour supplied would therefore be

$$\frac{\$3{,}600}{200{,}000 \text{ kw. hr.}} = \$0.018, \text{ or } 1.8\text{c. per kw.-hr.}$$

Having determined our cost per kilowatt-hour, the next problem is to determine a fair selling price for our current. Here again several factors must be taken into consideration. It may be that we are in competition with the local electric-light and power company, and it may be that we may have to regulate our price according to theirs. For example, if they are willing to contract with our firm to supply current for 1.9c. per kw.-hr., we would not be justified in charging 2c. for it. The least we could do would be to charge only as much as the lighting company offers the service for. We will not consider the possibility of the lighting company making a rate lower than our cost, because if such a thing were possible, we had better shut up shop.

Rate Must Meet Outside Competition

The point to be made is that where local service is available, our rate must at least meet it. However, if the local rate is very high, say 4c., we would not be justified in boosting our selling price to that figure if our cost is only 1.8c. We must remember that, after all, we are only one unit of a manufacturing establishment, and that if we charge exorbitant rates it will mean that the power house is showing a splendid profit, but that the manufacturing departments are showing only a very slim one because power is costing them so much that their cost of production is almost as much as what their product can be sold for.

It may be argued that if the local company charges 4c. we ought to be permitted to do the same because our firm could not buy power cheaper anywhere else, but that would be a false argument. If our concern had preferred to buy their power rather than make it, they would never have located their factory where they knew the power charge was high. Or if other considerations had led them to accept their present location in spite of the high power cost, they would have said to themselves, "This is just the location we need for our business. The only drawback is the high rate for power. But we'll settle here, anyhow, because we can put up our own power house and make our current for a whole lot less than the lighting company is asking." This goes to show that our only excuse for being on the job is that of turning out power at as cheap a rate as the firm could have bought it for if it had settled in some other locality where rates were low.

What, then, would be a fair method of arriving at a selling price when we don't have to meet a low rate from the public-service people? Ought we to add a certain percentage to our cost, the same as the manufacturing departments do? That would be a satisfactory method, but what shall the rate be? We must keep it as low as possible without being unfair to ourselves. We must not be swayed by jealousy of manufacturing departments that may show big profits. Let us remember that they must always pay us no matter what charges we run up against them, whereas they have to sell in competition with outside concerns. If they are making big profits today, they may be making small ones tomorrow, and the following day they may be losing, whereas, once we have established our rate of profit, we go along serenely charging it in each month without having to buck anyone else on price. We have no worries on the selling end. For these reasons we shall be satisfied to add only a small profit to our cost. Now what shall the rate be? The most sensible way to look at the problem is from the investment point of view. We know that we have a certain amount of capital tied up in the plant and it will not be unreasonable for us to expect to earn 6 per cent on that.

Determining the Selling Price

As an example, we will assume that our plant originally cost $100,000 and that it has since depreciated $15,000, so that its present value is really $85,000. Six per cent of this would be $5,100 a year, or $425 a month. This is the amount that we would be justified in adding to our cost each month. The rate of profit that we make on our power would then depend on our cost of production. The following example will make this clear: We find that in January our costs were $10,625; in February $7,083, and in March $8,500. Our percentage of profit on our cost would then be,

$$\text{January, } \frac{425}{10{,}625} = 0.04 = 4 \text{ per cent}$$

$$\text{February, } \frac{425}{7{,}083} = 0.06 = 6 \text{ per cent}$$

$$\text{March, } \frac{425}{8{,}500} = 0.05 = 5 \text{ per cent}$$

and the total of our charges to the various departments would be as follows:

January, 10,625 + 425 = $11,050
February, 7,083 + 425 = $7,508
March, 8,500 + 425 = $8,925

If, then, our production in these months had been

January, 581,579 kw.-hr.
February, 375,400 kw.-hr.
March, 495,833 kw.-hr.

we would find that our price per kilowatt-hour comes out to

$$\text{January, } \frac{11{,}050}{581{,}579} = \$.019 = 1.9\text{c.}$$

$$\text{February, } \frac{7{,}508}{375{,}400} = \$.020 = 2.0\text{c.}$$

$$\text{March, } \frac{8{,}925}{495{,}833} = \$.018 = 1.8\text{c.}$$

This method amounts to adding a fixed sum ($425) for interest to our cost each month, and it might therefore be construed as being an element of the cost. This, however, is not so. As more fully explained in a former article, interest on investment can never be entered as an element of cost. Only when interest is actually paid to outside parties can it be added into our costs. All that we have done in the present instance is to establish a profit that will give us as great a return as we could get if our money were invested in some other way. In fact, the profit that we indicate is a fictitious one. The concern as a whole will not benefit by it until the product

that used the power has been sold to outsiders at a profit. This phase of the matter will be gone into more fully a little later. Suffice it here to say that we must be very careful to keep all such profit charges strictly separate from any of our expenses, so that by no possibility can they become mixed in with any of these.

One other feature should be pointed out. It may happen at times that a concern is not making any money from any of its departments for a certain period, or perhaps it is even losing money on the business it does. In that case we should hardly expect to be paid a profit on our end of the business. The other departments are no more to blame for the poor business conditions than we are, and therefore, as a part of the establishment, we should shoulder our part of the burden.

Interdepartmental Profits

It is now desired to bring out some points that must be considered when we are dealing with a system of bookkeeping that allows one department to make a profit on what it sells to another; that is, when we are dealing with "interdepartmental" profits. For the sake of simplicity in our discussion we will make certain assumptions regarding our power plant, which will eliminate such elements as would only complicate matters without helping to improve the example. In the first place we will assume that the power plant is called upon to furnish electrical energy only. That is, no steam, compressed air, and the like is furnished to any of the departments. In the second place, we find that the local power company is prepared to furnish this electrical power at a rate that is only a little more than what it is costing us to generate it. Our average cost is 1.7c. per kw.-hr., whereas they are offering us a rate of 1.8c. per kw.-hr. We, of course, understand that under these circumstances our profit must be restricted to 1.8 — 1.7 = 0.1c. per kw.-hr., so that our price shall not exceed that of the power company, namely, 1.8c. per kilowatt-hour.

To proceed with our example, we find that in the month of April we delivered the following amounts of power:

Department A	100,000 kw.-hr.
Department B	200,000 kw.-hr.
Department C	75,000 kw.-hr.
Department D	125,000 kw.-hr.
Total	500,000 kw.-hr.

Our charges to the various departments and the amount of profit made on each of them are shown by the figures in the table herewith:

Dept.	Kw.-Hr.	Selling Price @ 1.8c.	Profit @ 0.1c
A	100,000	$1,800	$100
B	200,000	3,600	200
C	75,000	1,350	75
D	125,000	2,250	125
Total	500,000	$9,000	$500

It will now be necessary for us to digress for a little while to see what effect our charges are going to have on the business as a whole. In order to make our illustration as simple as possible, we will again make certain assumptions with the object of eliminating unnecessary complications. Instead of a big corporation whose factory consists of numerous departments, we will imagine ourselves as the sole proprietors of a small factory with just a single manufacturing department and a power plant. We have just bought the place and are about to begin operations. After paying for the factory, we have $10,000 left in our business bank. We go out and, for $4,000, buy enough material to start us off. Our financial condition before and after buying the material is as follows:

	Before	After
Cash	$10,000	$6,000
Material	none	4,000
Total	$10,000	$10,000

We have started business on the first of the month and during the month we use up all the material we bought. To do so we had to hire help and we find that the wages we had to pay amounted to $3,000. In addition to this we had all kinds of other expenses amounting to $2,000 and our power plant cost us $1,000 to operate. Consequently, our financial condition at the end of the month would be that shown by the schedule herewith: Cash, none; material, $4,000; labor, $3,000; expenses, $2,000; power, $1,000; total, $10,000.

From this it will be seen that we have transformed the $10,000 in money, with which we started, into finished product whose value is composed of various

Record of Watt-hour Meter Readings

Year 1920	Dept. A		Dept. B		Dept. C		Generator No.1		Generator No.2	
	Meter reading kw.-hr.	Difference between readings kw.-hr.	Meter reading kw.-hr.	Difference between readings kw.-hr.	Meter reading kw.-hr.	Difference between readings kw.-hr.	Meter reading kw.-hr.	Difference between readings kw.-hr.	Meter reading kw.-hr.	Difference between readings kw.-hr.
Jan. 1										
Feb. 1										
Mar. 1										
Apr. 1										
May 1										
June 1										
July 1										
Aug. 1										
Sept. 1										
Oct. 1										
Nov. 1										
Dec. 1										
1921 Jan. 1										

FORM FOR RECORDING ELECTRIC POWER DELIVERED TO VARIOUS DEPARTMENTS, ETC.

elements—material, labor, expenses and power. Until we sell this product, it is worth only $10,000. However, when we do sell it we expect to make a profit on it. To do this we must, of course, sell it for more than it cost us. Assume that on the last day of the month we sell the whole lot for $12,000. Our profit would ther be 12,000 — 10,000 = $2,000, and our financial condition would be this: Cash, $12,000; material, none; labor, none; expenses, none; power, none; total, $12,000. That is, we would have gotten rid of all the material, labor, expenses and power that we had soaked into our product, for $12,000 in money. This $12,000 could be considered as being divided in the following manner: Capital originally invested, $10,000; profit made during month, $2,000; total cash, $12,000.

Suppose now, that instead of putting in our power-plant expenses at cost—namely, $1,000—we had insisted on adding a profit to this cost and that the profit decided on was $50. Then our cost of manufacturing the product would have been $50 greater than shown before. That is, instead of being $10,000 it would have been $10,000 + 50 = $10,050. Then the profit on the sale of the product would obviously have been 12,000 — 10,050 = $1,950, instead of $2,000 as before. However, we have already made a profit of $50 on our power; the

total profit for the business would therefore be 1,950 + 50 = $2,000, so that we come out to the same amount after all. What it means is that the power plant has shown a profit of $50 and the manufacturing department one of $1,950.

Judging from our results, the foregoing would seem to be a perfectly reasonable and justifiable method of bookkeeping to follow. Unfortunately, however, it has the serious drawback that it leads us into self-deceptions if we are conducting the business for ourselves, or, what is worse, would cause us to deceive the people who had their money invested with us if we were conducting the business on any other basis than under our sole proprietorship. A careful consideration of what follows will serve to make this clear.

Cost Should Not Include Profits

Suppose, that instead of owning a business ourselves, we are merely hired by someone to run his business for him. At the end of each year or each month we would be expected to submit a report showing what we had accomplished during the period. We are now going to make up such a report in two ways—first, not including any profit on our power, and secondly, resorting to the method by which we do include such profit. Merely for the sake of our illustration we will grossly exaggerate the profit; the point that it is desired to make can be brought out much more forcibly in that way. Our report will be for a month, and it will show that at the beginning of the month our condition was this: Money in bank, $10,000; other items, none; total resources, $10,000. During the month we buy and manufacture a certain amount of raw material, turning it all into finished stock by the end of the month. To do so we put a certain amount of labor and other expenses into the product, including power. In doing so we had to spend $8,000 of our money, leaving us $10,000 — $8,000 = $2,000 in the bank. The cost of the power to the power house is $1,000, but we intend to make a fine showing for the power house, so the manufacturing department has been charged a profit of $1,500 on the power. That is, the total charge for power was entered as 1,000 + 1,500 = $2,500. As already stated, this exaggerated state of affairs is assumed merely for the sake of emphasizing the results to be shown.

Misleading Reports

We now wish to make up our monthly report. We will do this in two ways, as already suggested, one being exclusive of power-plant profit and the other inclusive of it. The two reports of our financial condition could be presented as follows:

	Exclusive of Profit on Power	Inclusive of Profit on Power
Money in bank	$2,000	$2,000
Finished goods	8,000	9,500
Total resources	$10,000	$11,500

Were we to hand our first report to the proprietor, he would see at a glance that he is worth $10,000. If we were to hand him the second one instead of the first, he would find himself to be worth $11,500. So far as the finished goods are concerned, he would not know what part of their value was labor, or material, or expenses, or power, or profit, or any other item. All he would know would be that he is worth $10,000 or $11,500, depending on which report we submitted to him, and that of that amount $8,000 in the one case or $9,500 in the other is soaked away in his stock of finished goods.

Now let us assume that we sell the goods for $9,000. Then if we were to make a report of the condition of the business, we should find the following for the two cases:

	Exclusive of Profit on Power	Inclusive of Profit on Power
Money in bank	$11,000	$11,000
Finished goods	none	none
Total resources	$11,000	$11,000

If we were to show the first of these to the owner, he would be pleased with the result because he would see that through the sale of his goods he increased his worldly wealth by $1,000. That is, after the sale he was worth $11,000, whereas in the report before the sale he was worth only $10,000. But what would the situation be if he were to analyze his condition according to the second method of making out the reports? He would find that before the sale he was worth $11,500, whereas after it he was worth only $11,000, showing that he had lost 11,500 — 11,000 = $500, on the sale. We should therefore quite naturally expect him to come down on us like a ton of brick. It would do little good to explain to him that his $9,500 worth of goods had really only cost him $8,000, and that therefore he was actually making $1,000 on the sale even if he thought he was losing $500, because he would already have made his future plans on the basis of having $9,500 worth of goods on hand.

Handling Departmental Profits

Even granted that we could explain such a situation satisfactorily to an individual proprietor, it is hardly likely that we would be listened to in a large concern. If anybody at the top were to discover such a situation, he might readily suspect us of intentionally misrepresenting conditions. It can readily be appreciated that if the amount of profit were small as compared with the power cost instead of being so exaggerated, it would get lost in the grand total and would never cause such a commotion as in the assumed case. However, the principle would be just as vicious. It would tend to show that a concern was making money even if it were not. What holds true about the power house selling power to the various departments of a mill, also holds true among those departments themselves.

How shall we get around this state of things? It looks as if we may not charge a profit, and yet we know that we are entitled to do so. The solution is this: The particular thing that we manufacture is only one constituent of many that go into the finished product that the factory makes and sells. Until the finished goods are sold, our concern makes no profit on them, neither on our contribution to the article nor that of any other department. When the article is finally sold, the profit may be distributed among all the departments that put anything into it. To do so before would only mean that the concern was digging down in one pocket to put money in another. Its condition as a whole would not be changed one iota. But when the goods are sold at a profit, then the concern *is* richer than it was before by the amount of the profit, and this can be divided in such a manner as to give each department its full share of credit.

The question, however, arises, How are we going to keep track of these individual profits on sales? The most usual way is actually to allow each department to

charge the other departments with a profit. But this profit is very carefully kept as an item entirely separate from any other so that it can be thrown out when arriving at actual worth. At the end of the month the accounting department goes over all the sales for the month and figures out how much of the profit set up in the departmental-profit account has actually entered into the sales. This amount is then available for whatever use it is to be put to, such as buying new apparatus or for distribution to the owners. The remainder of the departmental profit account is left standing to be added to and subtracted from as time goes on. It will never be wiped out as long as the factory is running, because there will always be a certain amount of product "in process" and in finished stock, and on this no profit can be collected, although it is chalked up for collection as soon as available.

So far as the power house is concerned, the chief things to remember are that the profit rate must be a reasonable one where public-service competition does not act as a check, and that when the profit is set aside, it must be carefully isolated and none of it used until we know that the company has cashed in on it. Provided we do this, there is no objection to charging a profit, because we can always separate this profit out of our charges to the various departments. By doing so we will never run into the error of causing the showing of these departments to be a fictitious one. Just how to handle all these details in our bookkeeping will be the subject of another article.

Belts and Their Care

By F. H. Sweet

In order that a belt may remain efficient, it must be kept pliable. No matter what kind of belt is used, there are two enemies at work to shorten its life—hardening of the fiber and slip.

Hardening can be avoided by the use of belt dressings, but all belts must not be treated in the same manner. For example, Scandinavia belts, which are solid-woven and filled with a bituminous dressing, can be kept soft and pliable by occasionally applying a dressing of the same material with which the belt is impregnated, or in place of this castor oil may be used.

For leather belts various dressings may be used, but leather-belt dressings should not be used on Scandinavia or other textile belts. The latter should have a liquid dressing that will soak well into the fibers. Liquid dressings should be applied warm and with a brush to the pulley side of the belts. Once a month is not too often.

Rubber belts do not require any dressing. Balata belting may need a little attention of this kind at times, but care is necessary in its use. The only time a balata belt requires dressing is when its pulley side becomes smooth and glossy. The dressing to be used is castor oil, and this should be put on with just a drop here and there. This, when sparingly applied, after the belt has been run, will give a "tacky" feeling to the surface of the belt, which will stop slipping. Too much oil or improper dressings will ruin such a belt.

For instance, two such belts were returned to the factory to have the ends respliced. On examination the belt was found to be soaked with oil which had dissolved the balata gum, allowing the splices to separate and permitting the plies to open up. The splices were made up again and the user was cautioned against applying oil or other dressing to this kind of belting. He admitted that bar belt dressing had been applied, as it has been recommended for use on leather belts and it was being used on all belts. Never use belt dressing of any kind on a balata belt and use only a very little castor oil.

Manufacturers are glad to give advice on the proper care of belting. Every belt should have a proper dressing applied occasionally to keep it in condition. By this means drying out is prevented and belts retain their gripping qualities on the pulleys, which means a retention of the original power transmission. A dressing containing resin or mineral oils should not be used, as these ingredients are detrimental. Never use a dressing containing animal oils on rubber, balata or stitched cotton-duck belting. The proper time to apply belt dressings is when the plant is closed down for a day or so—for instance, on Saturday, as by Monday morning it has had a chance to penetrate the belt. If kept in condition, there is no excuse for resorting to the questionable remedy of applying resin or other sticky dressing to get the proper power out of belts. A slipping belt is a serious evil and is often detected only by careful observation and by tests. The result of belt slip is cracking across width, and a cracked belt is evidence that it has been slipping.

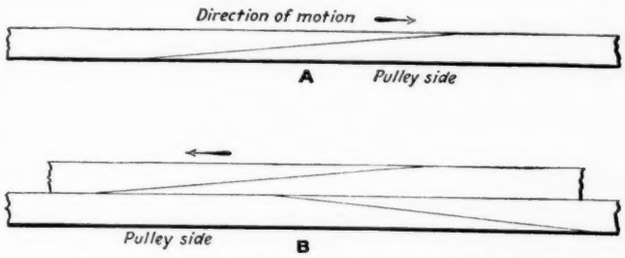


FIG. 1. SINGLE AND DOUBLE BELT SPLICE

When selecting belting, many things are to be taken into consideration. Assuming that a leather belt is to be used, uniformity in the material is of importance. It pays to purchase high-grade belt, for while the initial cost may be greater, the service received will more than make up for the extra cost. The belt should be thoroughly stretched before using so that it does not have to be "taken up" every few days.

Where exposed to the weather or to the action of steam, rubber belts are generally used, as they do not absorb moisture or stretch as readily as leather under like conditions. The best grades of such belting contain new rubber; lower grades are made largely of reclaimed rubber. High-grade belts contain heavy cotton duck; the cheaper grades have a lighter quality of duck. Provided the proper grade of duck is used, a three- or four-ply of belt of this nature is said to be equal in strength to a single leather belt. A five- or six-ply belt is about equal to a double leather belt, and so on in proportion.

An endless belt will run smoother than a jointed belt, as there is no obstruction to cause it to jump. Fig. 1 shows that the ends should be skived to a long, tapered, smooth, even surface, keeping the ends square with the edges. Depending on the width of the belt, the length of the lap can vary, and the following figures have been found to give excellent results: For a 1-in. width belt, length of lap 5 in.; 2-in. belt, 5 in.; 3-in. belt, 6 in.; 4-in. belt, 6 in.; 5-in. belt, 7 in.: 6-in. belt, 8 in.; 7-in. belt,

8 in.; and 8-in. belt, 9 in. of lap. Above this width the length of lap is usually made equal to the belt width, and after 18-in. widths have been reached, the lap need go no longer than this amount.

Generally, before cementing a joint the belt should be placed over the pulleys and proper tension obtained by means of clamps. After drawing a little tighter than is necessary, to allow for slack, bevel the ends to form the lap and apply the cement to both surfaces while hot. Should the belt be a large one, cement only a few inches at a time and then hammer down the cemented section thoroughly, proceeding in this manner until the complete joint has been cemented. The joint should also be hammered carefully along the edges. The clamps should be left on for at least an hour after cementing, longer if possible.

In the case of the smaller belts the cemented lap is often clamped between boards to which the belt has been previously tacked in position. Various cements are used.

Referring to Fig. 1, it will be noted that the point of the lap *A* is on the pulley side so as to prevent the end from opening should the belt slip on the driving pulley.

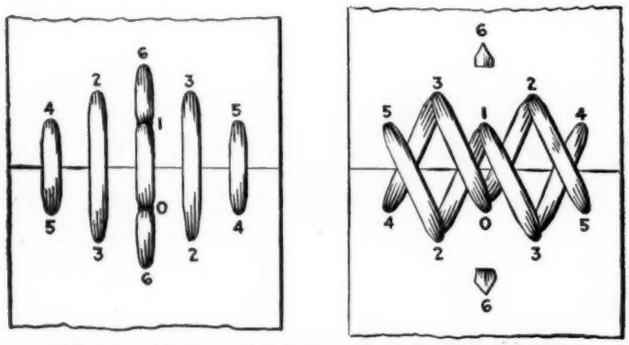


FIG. 2. LACING ON FACE AND TOP SIDE OF BELT

Where the point is in the opposite direction, the tendency is to open up in case of slippage. However, the edge on the top side may open up, due to windage. On a double-ply belt the laps should be arranged as shown at *B*. With this arrangement the points of the laps in both single- and double-ply will be on the inside, and the face of the pulley tends to keep the edges of the lap in place.

There are several ways of lacing belts. Fig. 2 shows a satisfactory method. When making a laced joint, cut the ends of the belt square and do not make the holes any larger than necessary, or the material will be weakened at the punched section. Use a strong thin lace in preference to a thick one. The thinner the lace the less will be the jar on the belt as it goes over the pulley. The straight lacing should always be on the pulley side, and as a general rule the number of holes for belts of various widths can be as follows: For 1-in. to 2-in. belts, $\frac{1}{4}$-in. wide lacing is sufficient, and three holes in each side of the joint will do. From 2-in. to $4\frac{1}{2}$-in., three to five holes at each side is right, and from 3-in. to 5-in. seven holes will be found enough. From 6-in. on, nine to seventeen holes are usually punched, depending on conditions and the nature of the drive. The lacing usually adopted ranges from $\frac{1}{4}$-in. in the smaller size to $\frac{1}{2}$-in. in the larger belting, but up to 6-in. width, $\frac{3}{8}$-in. lacing will be strong enough.

The distance that the holes should be punched from the end remains an open question, but good practice calls for the first row in the smaller belts ranging from $\frac{3}{8}$ in. to $\frac{1}{2}$ in. from the end, the second row being back from $\frac{3}{4}$ in. to 1 in. Above 4-in. width the holes go back a proportionate distance.

The best practice is to begin at the center and work out and back on each side. Starting at 0 and 1, the order is as follows: 2, 3, 4, 5, 4, 3. 2, 1, or 0, both sides of the center being identical. The locking is done by passing the free end through a small hole 6, and cutting a short slit to form a hook that will prevent the lace from coming out. This lock should be on the outside of the belt, and after it is made, it should be lightly hammered down.

The various methods of fastening belts by steel and other types of fasteners require no comment. When metal wire is used, a special machine is employed in conjunction with the fastener. Other fasteners are hammered into place, the teeth clamping on the pulley side of the belt.

When a belt runs wobbly, or races back and forth across the pulleys, it is not giving its best service, nor will it last long under such conditions. With such a trouble investigate the joints, see if they are cut square, and ten to one it will be found that here is where the trouble lies.

The size of pulley largely determines the life and service of a belt. The larger the pulley the less the strain, therefore it is advisable to keep the pulleys as large as can be used.

Belts used in sawmills and other plants that are shut down during the winter months, should be taken off, rolled up and kept in a warm place. If left on the pulleys and exposed to the changeable atmospheric conditions of winter, they will deteriorate somewhat by spring. Carelessness in starting machinery too quickly will cause a belt to slip on a pulley. This can be avoided largely by putting on the power gradually, which gives the belt a chance to get a grip on the pulleys.

Another important matter is to have proper alignment of pulleys, as many belts give out before their time owing to defects in this respect. Another mistake made by some belting users is practicing false economy in getting belts too light for the work. Although a certain weight of belt may at first do the work required, if it is necessary to keep it under a constant strain to accomplish this, both belt and machinery are going to wear out much faster than if the belt were of greater capacity. In other words, a belt should be used that will not be overstrained. The cost may be a little more at first, but it will pay in the long run.

In conclusion it is suggested that some system be adopted whereby a record can be kept of the different belts and their performances. For example, suppose a belt is required. Place a steel tape over the pulleys and determine the correct length. Place this length, together with other particulars of the belt to be used, the nature of the drive, etc., on a card, keeping this on file. State the date of application and leave spaces to record when the belt needed repair, when it should receive dressing, etc. Do not forget the cost. Do not be afraid to put everything of importance on the card, for this is the only true method of actually knowing what a belt is costing and what grade is standing up best. If such a plan is inaugurated, there will be less idle machinery in manufacturing plants, the engineer will have correct data regarding the belts under his care and there will be no guesswork as to what particular type of belt is the best.

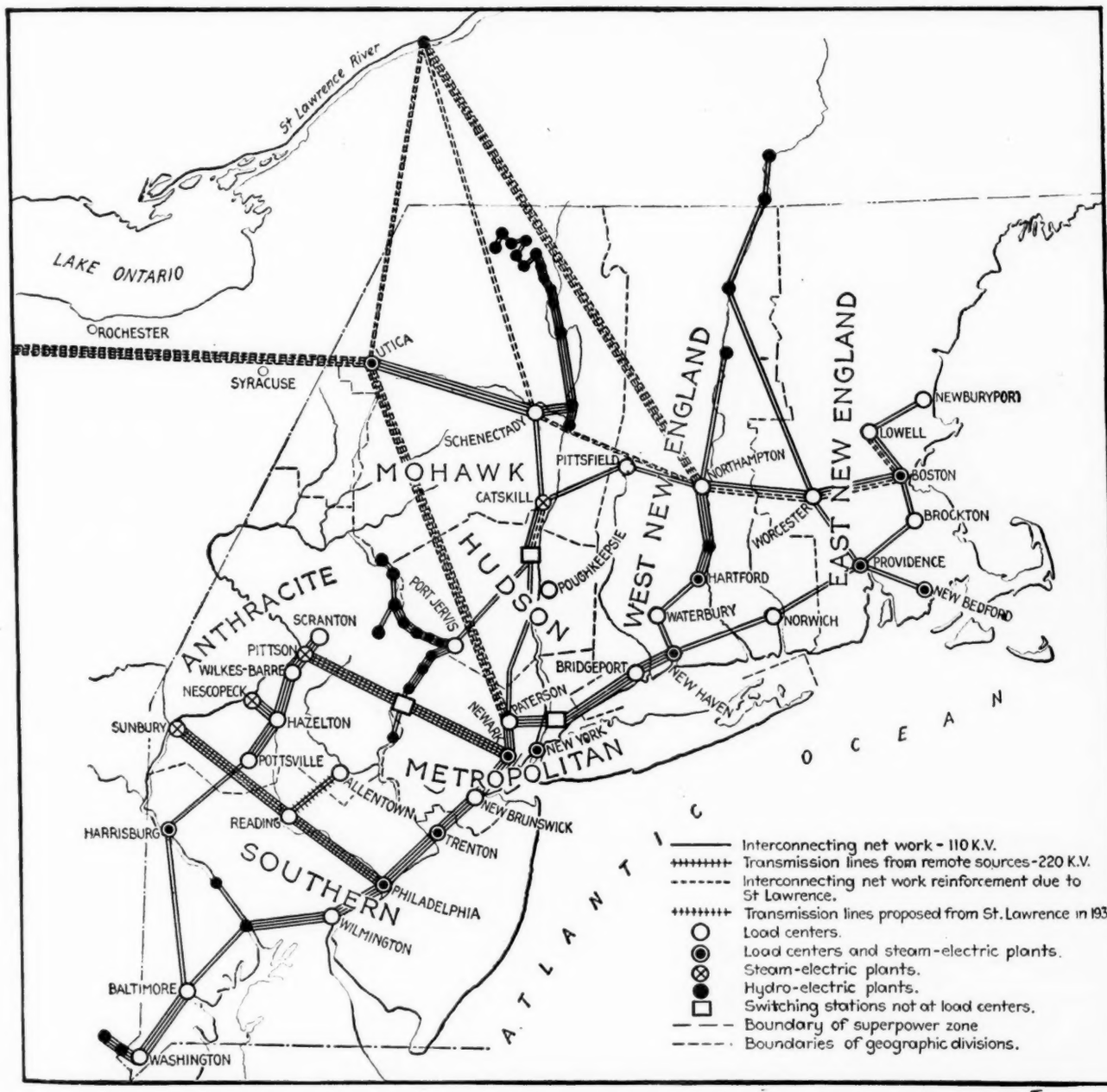
The Performance and Cost of the Superpower System

By ARTHUR R. WELLWOOD
Formerly Assistant Engineer-Secretary, Superpower Survey

AS A RESULT of the work of the Superpower Survey it is now possible to present some of the vital facts concerning the performance and cost of the Superpower system.

The zone chosen for the investigation just completed lies along the North Atlantic seaboard between Washington and Portsmouth, New Hampshire, and inland from the coast an average of approximately 150 miles, as shown on the accompanying map. For the purpose of the survey, this territory was divided into geographic divisions and each of these into load centers.

In this zone it is proposed to construct a Superpower system consisting of steam-electric and hydro-electric generating plants strategically located, and an interconnecting network of transmission lines designed to furnish energy to the various load centers at maximum efficiency and minimum cost. All the present hydro-electric plants in this zone, as well as 80 per cent of



MAP OF SUPERPOWER ZONE, SHOWING GEOGRAPHIC DIVISIONS AND THE SUPERPOWER SYSTEM FOR THE YEAR 1930

the present steam-electric plants, would automatically become a part of the project known as superpower.

Distinct studies were made for the years 1919, 1925 and 1930.

The 1919 statement is hypothetical in that it considers the situation as it might have been had Superpower been in operation during that year. The 1925 and 1930 statements are estimates of a construction program based upon the data furnished by the electric utilities in the zone. These estimates represent the co-ordinated opinions of the engineering staff of the Superpower Survey, assisted by the advice and counsel of many experts on power generation and distribution.

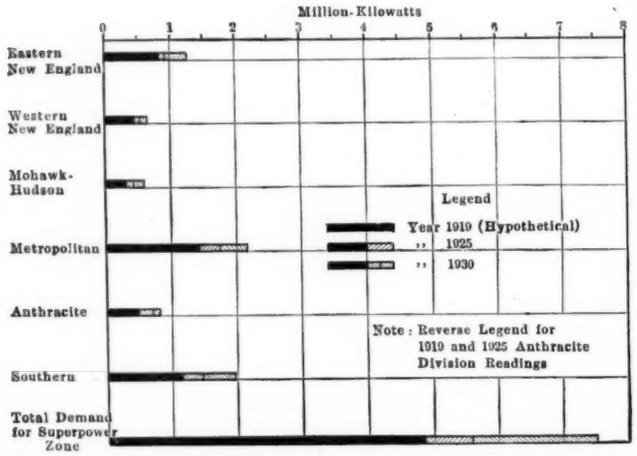


FIG. 1. POWER DEMAND IN MILLION KILOWATTS BY GEOGRAPHIC DIVISIONS AND FOR SUPERPOWER ZONE FOR YEARS 1919, 1925 AND 1930

Power and Energy Requirements

The power and energy requirements to be satisfied by the Superpower system are given by geographic divisions and for the whole zone for the years 1919, 1925 and 1930 in Figs. 1 and 2. These estimates are based on past rates of growth together with the load growth of the electric utilities, the industries and the railroads within the zone. The future growth of the electric utilities was estimated almost entirely by the executives of the electric utility companies.

The 1919 figures are hypothetical in that they consider the peak demand for power and the energy which might have been supplied more economically by the Superpower system. The power demand figures were derived by using the load factor of the energy which was actually supplied to the load centers in that year. This is a conservative basis for such an estimate, when it is considered that the character of the railroad and industrial load would tend to raise the load factor above the actual 1919 figure.

In addition to the energy actually supplied by the electrical utility companies to their consumers, there is included in each yearly figure, first, the portion of the energy generated by the isolated plants of the industries which might have been more economically supplied by the Superpower system, and second, the energy used by those heavy-traction railroads which can be economically electrified.

Decentralization

A striking example of the possibilities of decentralizing the cencentrated load districts in the Superpower zone is shown in Fig. 3. This chart gives the load at each center referred to New York as 100 per cent, and shows the better distribution of load between the different load centers resulting from the relatively larger growth of the heavy-traction railroad and the industrial loads, which will relieve the congestion at the large centers. It will be noted that there are 14 more load centers in 1930 than in 1919. These are required in order to provide sufficient future facilities for the proper delivery of energy to each district.

Frequency

When compared with England, this country is fortunate in regard to the matter of frequency. There are but two prevailing frequencies in the United States, namely, 60 and 25 cycles. In the area of Greater London there are some 70 generating stations with fifty different types of systems, 10 different frequencies and 24 different voltages. With a chaotic condition such as this, any attempt to standardize would be both difficult and expensive.

In the Superpower zone there is a predominance of 60-cycle energy in each geographic division except the Metropolitan and Southern divisions. This is readily observed by reference to Fig. 4, which shows the percentages of power generated at different frequencies in each geographic division during 1919. The Metropolitan and Southern divisions contain four of the five most densely populated load centers, namely, New York, Philadelphia, Baltimore and Washington. The Eastern New England division contains the fifth, Boston. The percentages of energy generated at different frequencies in these five load centers are shown in Fig. 5, while Fig. 6 gives the percentages for the remainder of the Superpower zone.

The actual 25- and 60-cycle output of the electric utilities in the Superpower zone for the years 1910 to 1919 inclusive is given in Fig. 7. This chart shows the steady growth of 60-cycle over 25-cycle power, and from its upward trend indicates its predominance in the near future. The street railways are the principal users of 25-cycle energy. This accounts in a large measure for the predominance of this form of energy in densely populated centers. The reason for the use of 25 cycles by the railways is that 25-cycle rotary converters were developed before 60-cycle converters were practicable.

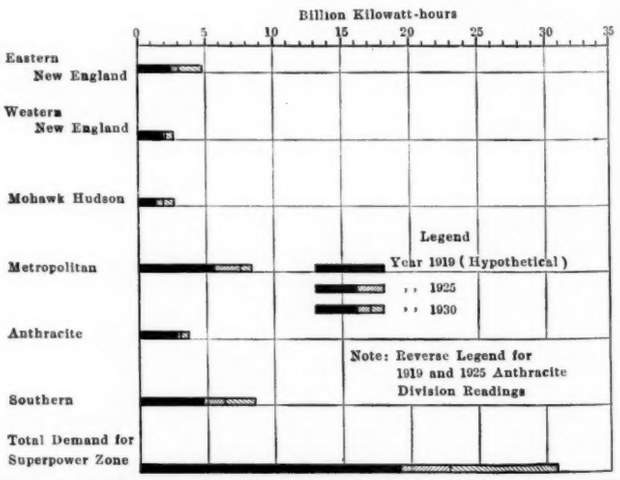


FIG. 2. ENERGY REQUIREMENTS IN BILLION KILOWATT-HOURS BY GEOGRAPHIC DIVISIONS AND FOR SUPERPOWER ZONE FOR 1919 AND 1930

An analysis of the sales of generating equipment in the Superpower zone for the period 1914-1919 is given in Table I.

TABLE I. DIVISION OF 60- AND 25-CYCLE GENERATOR SALES IN THE SUPERPOWER ZONE

	60 Cycle Per Cent	25 Cycle Per Cent
1914	74	26
1915	63	37
1916	57.5	42.5
1917	54.5	45.5
1918	86	14
1919	86.5	13.5

This table shows that the volume of sales is in the 60-cycle frequency and that since 1917 there has been a noticeable dropping off in the 25-cycle frequency. The average money saving from the use of 60 cycles is large and for the whole zone could probably be taken at nearly 20 per cent of the necessary investment in power plants, sub-stations, distribution systems and customers' equipment. Sixty-cycle energy is free from light fluctuations, which are characteristic of the lower frequency. In some industries, however, where slow speed motors are used, and for street railways, where the energy is converted to direct current, there is reason for continuing the use of the lower frequency, owing to the larger investment already made in 25-cycle equipment. In view of the rapid gain of 60-cycle energy this frequency has been adopted as the standard for the Superpower system.

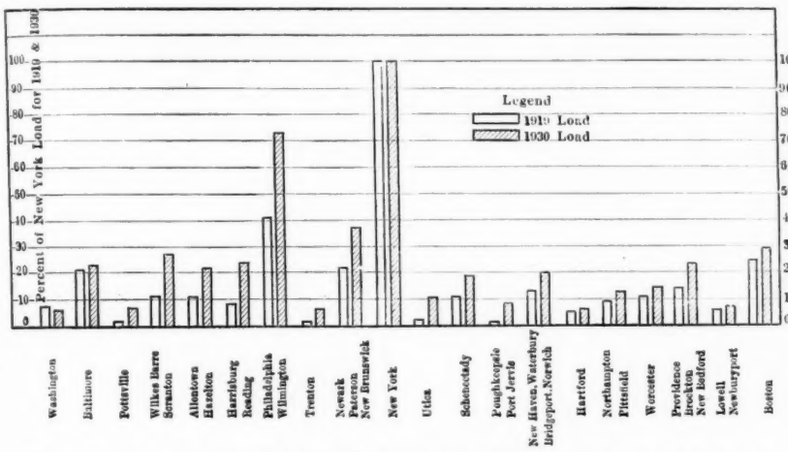


FIG. 3. LOAD AT THE SEVERAL CENTERS REFERRED TO NEW YORK AS 100 PER CENT, FOR 1919 AND 1930

Illustrating the better distribution of the load through the growth of heavy-traction railroad and industrial loads. In 1930, the 20 load centers for 1919 have been expanded to 34. The first name under each group is the original load center.

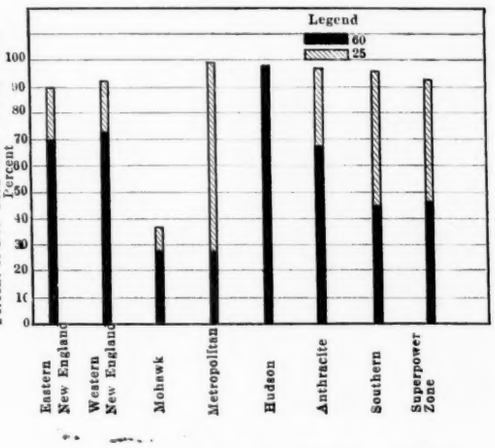


FIG. 4. POWER GENERATED AT 25 AND 60 CYCLES

Percentage of total amount of power generated at the two frequencies in the different geographic divisions of the superpower zone, in 1919.

Past and Estimated Future Load Growth

Fig. 8 shows the past and estimated future load growth of the Superpower system by geographic divisions and for the entire Superpower zone. These figures include the energy for industrial and domestic use and for electric railways, but do not include the energy which would be utilized through the electrification of 19,000 miles of heavy-traction railroads in the zone. The 1925 and 1930 figures represent the estimates of the future growth as submitted by the electric utilities.

Load Factor and Diversity

As a result of a study of the load-factor conditions in each geographic division covering a period from 1910 to 1919, it was discovered that the load factor for all electric utilities in the zone started at 34 per cent in 1910 and rose to 39.7 per cent in 1918, dropping off to 38.6 in 1919. Discounting the higher load factors in 1917 and 1918, which were due to war conditions, it is estimated that the load factors will increase to about 42 per cent in 1925 and about 44 per cent in 1930, through additions to utility loads only. By adding the heavy-traction load which could be economically taken over, these load factors would be raised to about 44.5 per cent for 1925 and 47 per cent for 1930. The improvement between 1910 and 1919 has been caused largely by: The interconnection of utility companies; the interweave between individual customers' demands; the increase of off-peak load.

It is interesting to note how load factor is affected by local load conditions. For instance, in a load center such as Allentown, where the ratio of industrial to lighting load is high, the load factor during the last ten years has increased from 40 per cent to a maximum of 56 per cent, while in another load center such as New York where the industrial load is relatively small, the increase in load factor during the same period has been only from 35 per cent to 37 per cent.

The character of diversity present in the Superpower zone affords a strong advantage to the Anthracite, Southern and Metropolitan divisions. The peak in the Anthracite division is controlled by the mining industries and comes in the morning, falling off rapidly about three p.m. The industrial load conditions in the Southern and Metropolitan divisions permit of a combination with the Anthracite division which should yield a considerable saving in the production of power. The necessary interconnection in the transmission system can be justified through the savings in production costs. Diversity acted as a considerable aid in determining the capacity required for the Superpower system in 1925 and 1930; however, the actual estimated requirements were arrived at through a study of the trend of load-factor for each of the individual load centers concerned.

Generating Facilities

The generating facilities required to satisfy the power and energy requirements of the proposed Superpower system are shown in Table II. By comparing the 1919 actual figures with those of the 1930 estimates in

Table II, it is found that, for this ten-year interval, the energy output will have been tripled, and that the total power-plant capacity will have been practically doubled. The smaller proportion of reserve in 1930 compared to the actual 1919 reserve is brought about through the interconnection of the various systems in the zone.

Approximately 80 per cent of the existing steam-electric central stations have been retained as a part of the Superpower system, together with all the exist-

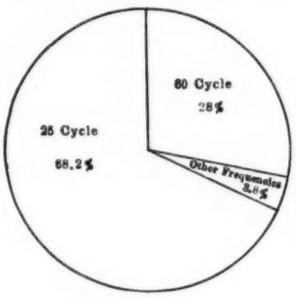


Fig. 5

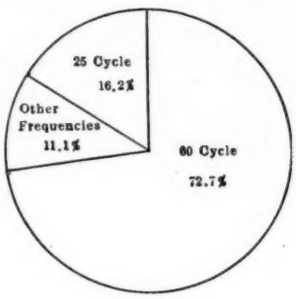


Fig. 6

FIGS. 5 AND 6. POWER GENERATED AT DIFFERENT FREQUENCIES

Fig. 5—Percentage of power output generated at different frequencies, in 1919, in the five principal load centers. Fig. 6—Percentage of power output generated at different frequencies, in 1919, in the Superpower Zone outside of the five principal load centers.

ing hydro-electric plants in the zone. The retained steam-electric plants were chosen as a result of a detailed study and analysis of their 1919 performance. In 1930 these retained plants will be operated at an annual capacity factor of 20 per cent. The new power plants will be operated at an annual capacity factor of 60.3 per cent. The reason for this condition is the better plant performance, which will be obtained through the operation of the new base-load type of plants at high annual capacity factors.[1] The existing plants retained as a part of the system will carry peak loads and operate at low annual capacity factors.

Of the total power plant capacity provided for in the year 1930, 81.5 per cent is in steam-electric plants and 18.5 per cent in hydro-electric plants. The steam-electric

TABLE II. CAPACITY AND OUTPUT OF GENERATING EQUIPMENT

Year	Plant Capacity, Thousand Kw.	Peak Demand, Thousand Kw.	Plant Reserve, Thousand Kw.	Energy Output, Millions Kw.-Hr.	Annual Capacity Factor
1919 (actual)	4,451.7	3,055.0	1,396.7	10,301.1	30.7
1919 (hypothetical)	5,656.1	4,854.0	802.1	20,156.0	40.5
1925	6,226.1	5,602.0	624.1	23,814.0	43.7
1930	8,108.1	7,422.0	686.1	31,946.0	45.0

plants will operate at 43.7 per cent capacity factor, satisfying 79.2 per cent of the output. The hydro-electric plants will operate at 50.5 per cent capacity factor and furnish 20.8 per cent of the output.

In 1930 the new power plants will provide 61.4 per cent of the total power plant capacity required and will supply 82.1 per cent of the energy output, the existing power plants furnishing the balance, or 17.9 per cent.

The new base-load steam-electric plants will be located outside of the densely populated districts, at such points where sufficient quantity of condensing water can be obtained and where coal delivery and storage facilities will permit of the economical handling of fuel. The new steam-electric plants provided for in 1930 amount to 48.5 per cent of the total power plant capacity required; they will operate at an annual capacity factor of 61.8 per cent and furnish 66.7 per cent of the output.

The principal hydro-electric developments included in the production facilities for the Superpower system are those on the Potomac, Susquehanna, Delaware, Hudson and Connecticut rivers. These rivers will be developed for an ultimate capacity of 1,050,000 kw. for the year 1930. This capacity represents about 13 per cent of the total power-plant capacity required in 1930. The plants will operate at an annual capacity factor of 55.2 per cent. The water powers of the Niagara and St. Lawrence rivers have not been included in the hydro-electric capacity available for the 1930 requirements in the Superpower zone. The reason for this is the time required for the construction of the St. Lawrence development and the additional capacity of Niagara Falls available for the Superpower zone.

Fuel Requirements

The total net tons of coal required for the Superpower system in 1930 will be 20,551,000. Of this amount the new steam facilities will utilize 74 per cent. This tonnage represents, at an average cost of $5.25 per net ton delivered, a total of $108,094,000.

The average performance and fuel rate of the retained and the new steam-electric plants for the year 1930 is shown in Fig. 9. This indicates the great possibility for fuel economy through the agency of a Superpower system. The average fuel rate of all the electric utilities in the zone for the year 1919 was 2.73 lb. per kw.-hr. The coal that would be required at the 1919 fuel rate for electric utilities in order to satisfy the 1930 demands for steam-produced power would be 39,700,000 net tons. Comparing this coal consumption to that of Superpower operation, the annual fuel saving in favor of Superpower is found to be 19,149,000 net tons. At the average cost of $5.25 per net ton of coal delivered, the money saving is found to be $100,500,000

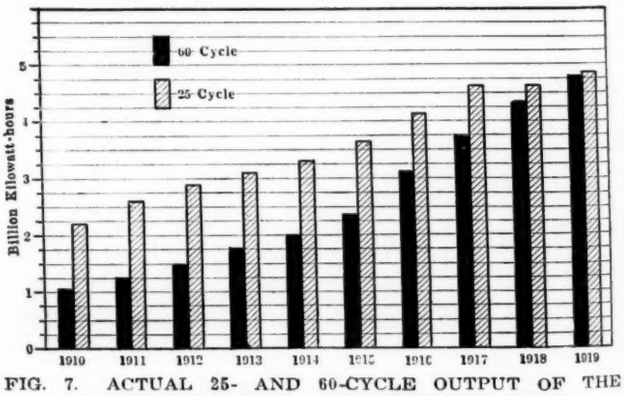


FIG. 7. ACTUAL 25- AND 60-CYCLE OUTPUT OF THE ELECTRIC UTILITIES IN SUPERPOWER ZONE DURING THE PERIOD 1910 TO 1919

for 1930. There is a further conservation of fuel brought about through the operation of the Superpower system. The heavy-traction railroads' portion of this saving is approximately 10,000,000 net tons and the manufacturing industries contribute about 20,000,000 net tons. This makes a total saving in fuel of approximately 49,000,000 net tons.

In general, it is proposed to tie in the various load centers in the Superpower zone by interconnecting lines operating at 110,000 volts, and to construct lines of

[1]Capacity factor is the average load on a plant expressed as a percentage of the effective capacity of the plant.

large capacity designed to transmit energy at 220,000 volts from the new hydroelectric plants and from the new steam-electric plants located at the coal mines. These latter lines will generally be used for base load supply, operating at high load factor. Continuity of service is insured by the interconnecting network, as most of the principal load centers have eight incoming

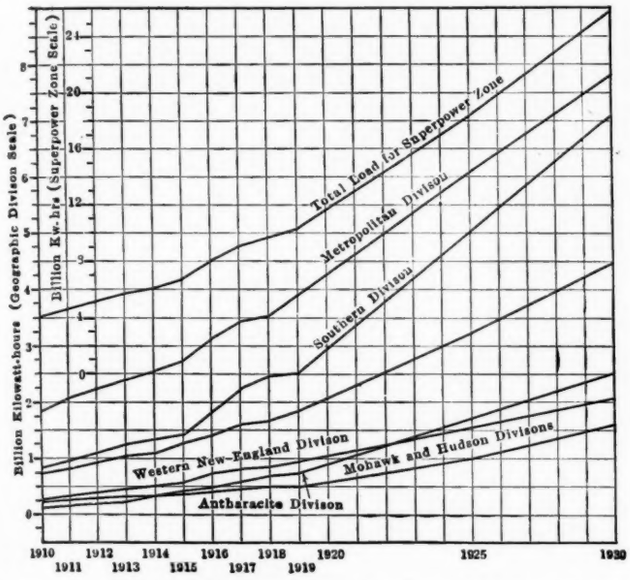


FIG. 8. PAST AND ESTIMATED FUTURE LOAD GROWTH FOR THE SUPERPOWER SYSTEM, BY GEOGRAPHIC DIVISIONS AND FOR THE TOTAL ZONE

lines serving them, four from each direction. In 1930 the total circuit miles required for 220,000-volt lines is 970 and for 110,000-volt lines is 4,696.

Investment Cost

The total investment cost in present and new facilities for the year 1930 is $1,109,564,000. This amount includes the present facilities retained as a part of the system, and the new facilities, including transmission lines and sub-stations. The investment in present facilities retained as part of the Superpower system, based on prices as of midyear 1919, is $416,346,000. The new capital required, therefore, is, for the year 1930, $693,218,000.

The 1919 reproduction value of all the power plants of the electric utilities was $598,277,000, or $196 per kilowatt of demand. If, therefore, the independent systems were to provide for the demand in 1930 it would require $856,000,000. On this basis it is readily seen that the construction of a Superpower system would accomplish a saving in investment cost of $163,000,000 during the next decade.

The unit investment costs per kilowatt of installed capacity are shown in Table III. It will be noted that

TABLE III. UNIT INVESTMENT COSTS PER KILOWATT OF INSTALLED PLANT CAPACITY

	1919	1925	1930
New steam-electric plants	112.00	110.60	109.50
New hydro-electric plants	151.90	151.90	151.30
Total new facilities	121.10	118.40	118.25
Midyear 1919 reproduction cost:			
Retained present steam-electric plants	123.00	123.00	123.00
Retained present hydro-electric plants	193.60	193.60	193.60
Total retained existing plants	133.00	133.00	133.00
Total all power plants	127.80	125.80	125.00

the unit cost of the existing plants retained is higher than that of the new facilities. This is caused by the smaller individual capacities of the present plants retained and of the construction of the most economical hydro-electric developments on a peak load basis.

Annual Cost of Power Delivered

Fig. 10 compares the average annual cost of power delivered in 1930 by the Superpower system with the annual production cost of the independent electric utilities for each geographic division and for the total zone. The 1919 electric utility figures represent the cost of power at the company's busbars and the Superpower system costs represent the selling prices of power at the receiving company's bus voltage. The total saving by Superpower operation in 1930 for the entire zone is approximately nine-tenths of a cent per kilowatt-hour, or $278,533,000.

The 1919 costs given in Fig. 10 for the electric utilities include the actual operating expenses of the companies. These are made up of fuel, labor, maintenance and supplies. The 1930 operating costs for the Superpower system are based upon estimates furnished by the many authorities and experts who took part in the work of the survey. Production costs in each case consist of operating expenses and fixed charges. To the Superpower system production costs have been added the annual transmission system costs. These include the

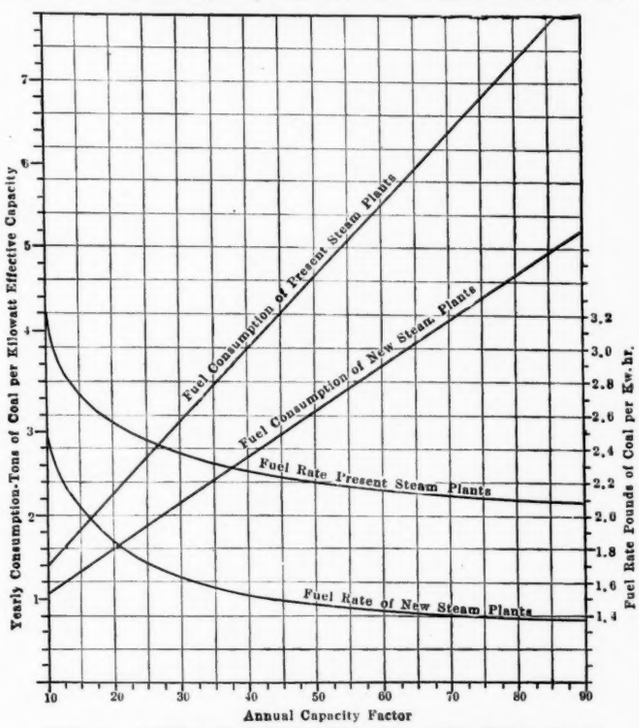

Yearly Consumption-Tons of Coal per Kilowatt Effective Capacity
Fuel Rate Pounds of Coal per Kw.hr.
Fuel Consumption of Present Steam Plants
Fuel Consumption of New Steam Plants
Fuel Rate Present Steam Plants
Fuel Rate of New Steam Plants
Annual Capacity Factor

FIG. 9. AVERAGE PERFORMANCE AND FUEL RATE OF THE RETAINED AND NEW STEAM-ELECTRIC PLANTS[2] FOR THE SUPERPOWER SYSTEM OF 1930

usual operating expenses for transmission lines and substations plus a percentage for fixed charges.

The annual cost of power delivered by the Superpower system is, therefore, a total of: The annual production cost; the annual transmission system cost; general expense.

Fixed charges in all cases include an item of ten per cent which represents the cost of money. The cost of money is made up of interest charges, bond discounts

[2]Effective capacity as used in this diagram is the rated capacity of a plant as limited by boilers, prime movers or generators.

and profit. By the use of this item the annual cost of power delivered represents the sales price to the purchaser. The other items included in fixed charges are depreciation and obsolescence, and taxes and insurance. The percentages used for these charges vary with the particular class of construction involved.

General expense includes the following items: Salaries and expenses of administrative officers, engineers and legal talent; salaries of clerks; claims; general stationery and printing; store and stable expenses. An analysis of the general expense item of the utilities located in the zone revealed the fact that the percentage

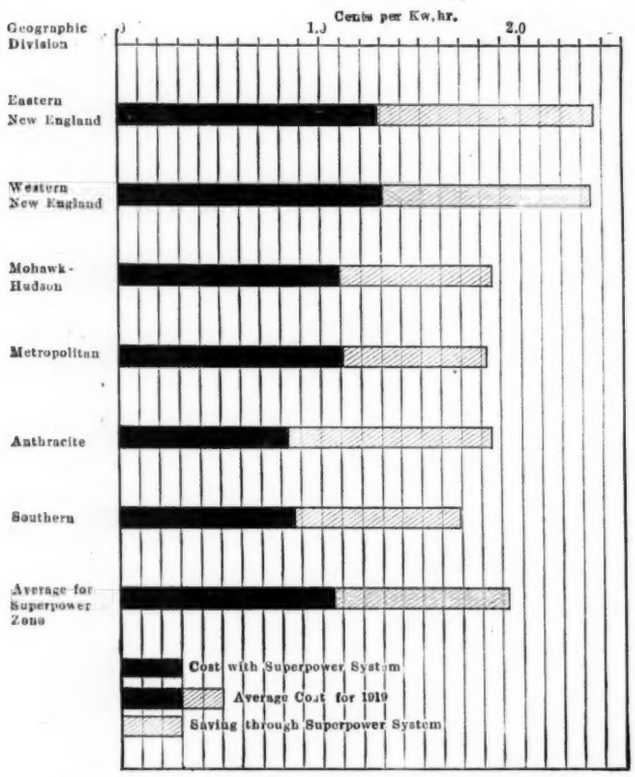


FIG. 10. YEARLY AVERAGE COST OF POWER IN THE SUPERPOWER ZONE FOR 1919 AND 1930, SHOWING SAVING IN COST EFFECTED BY SUPERPOWER SYSTEM

varied from 10.5 per cent for a large number of utilities to 3.5 per cent for companies with a gross revenue in the neighborhood of $5,000,000 per annum.

Net Annual Saving

The cost of money, insurance and taxes on the plants not retained as a part of the Superpower system is $21,800,000 per annum. On a 7 per cent annuity basis these plants will be amortized in about eight years through the provision of a sinking fund of $17,800,000 per annum. The net annual saving for 1930 is, therefore, arrived at by deducting the cost of money, insurance, taxes and amortization for these plants from the gross saving by Superpower operation. This amount is $237,933,000 for the year 1930.

From the foregoing facts and figures, it is obvious that an interconnected system, such as the Superpower plan proposes, will afford a much more economical means of delivering power to the principal load centers in the zone. This is made possible through the construction of base-load steam-electric plants located at tidewater, on inland rivers and near the coal fields, as the study of local conditions warrants. Another contributing factor is the development of hydro-electric plants, where water power is available, for the purpose of carrying peak loads. The market for the supply of energy from the Superpower system would be the utilities, the industries and the railroads.

The order in which the superpower steam-electric and hydro-electric power plants and transmission systems should be constructed must depend (1) on the present industrial demand for energy that cannot be satisfied because of the difficulties of the local utilities in financing extensions, and (2) on the future demand for energy that will result from the more economical generation of power under the Superpower System. It is believed that the quickest return will be obtained by following in chronologic sequence the order of procedure as follows:

1. The construction of a steam-electric plant near Pittston, Pa., to supply a part of its energy to the anthracite division of the Superpower Zone and the remainder to the metropolitan division, particularly New Jersey.
2. The construction of a steam-electric plant near Sunbury, Pa., to supply a part of its energy to the anthracite division, a part to the Reading load center, and the remainder to Philadelphia.
3. The construction of hydro-electric plants on the Delaware and Susquehanna Rivers to supplement the steam plants indicated above.
4. The progressive development of the Hudson River projects to meet the growth of energy requirements at the Schenectady, Utica, Poughkeepsie and Pittsfield load centers.
5. The construction of a steam-electric plant near Boston to supply the Boston, Lowell and Newburyport load centers.
6. The construction of a steam-electric plant near New Haven to supply the New Haven, Bridgeport, Waterbury and Norwich load centers.
7. The partial construction of the first hydro-electric plant in the development of the Potomac River as soon as the power demands of the Baltimore and Washington load centers require additional plant capacity.

Due credit should be given the electric utility companies in this country for the progress already made in the matter of reducing power costs and conserving fuel. However, it cannot be denied that there is still large room for improvement and that this improvement is of vital importance to the country's economic interests.

In another part of this article, reference was made to Great Britain and her chaotic frequency condition. That country is not alone in her efforts to bring about a cheaper means of producing power. Switzerland, Holland, Italy and Germany have all realized the condition brought about as a result of the war, and are making steady progress in the unification of their power systems. If the United States is to retain her supremacy in the world's market, some action must be taken in the matter of lowering production costs. The Superpower plan carrying out the principles that have heretofore governed the expansion of our present power system, offers a partial solution of the problem.

Acknowledgment is made to the Superpower Committee and its chairman, W. S. Murray; also to George Otis Smith, Director of the U. S. Geological Survey, under whose direction the investigation was made.[3]

[3]For personnel and organization of the superpower committee, see *Power*, Aug. 24, 1920.

EDITORIALS

The Superpower Report

THE Superpower report has just been released by the United States Geological Survey. Representing the combined efforts of a staff of expert engineers, guided by an advisory committee containing the best engineering thought of the country, and with the hearty co-operation of the public utilities, the report contains a wealth of material that is deserving of careful study. The investigation, it will be recalled, was made under a Congressional appropriation at the instance of W. S. Murray, who had conceived the economic possibilities of a power system serving the industries, utilities and railroads of the region from Washington to Boston and extending north to the St. Lawrence. Although following a somewhat different method of procedure, the project is not unlike the interconnected system that has grown up in the Middle West. Its primary object is to attain the benefits of maximum diversity, with its attendant reduction in generating cost, less reserve capacity, lower investment cost and greater assurance of continuity of service, at the same time providing for an energy supply that will be adequate to meet the industrial growth and power requirements up to 1925 and 1930.

There are several outstanding features of the report that bear emphasis. The estimated investment in generating and transmission facilities for the Superpower System is over a billion dollars, of which close to half represents the value of existing facilities that would be incorporated in the system. It is planned to utilize eighty per cent of the present steam-electric stations and all the efficient water-power developments in the zone, supplementing these by certain steam-electric base-load plants located at advantageous load centers, and additional water-power developments. In 1919 only fifteen per cent of the load was carried by hydroelectric plants; by 1930 this would be increased to twenty-one per cent. This takes into consideration further developments on the St. Lawrence which, by means of long-distance transmission lines tying into the system, would save over eleven millions a year in the cost of energy. Moreover, the total investment to utilize purchased St. Lawrence power would be twenty-five millions less than that required to construct enough steam-electric plants to supply this energy. Yet with this comprehensive development of water power it is apparent that steam power must still supply the bulk of the energy required.

In the opinion of the committee about half of the railroads could be profitably electrified, representing an annual saving of eighty-one million dollars as compared with operation by steam. The performance of the retained plants would be increased from a present average of 2.73 pounds of coal per kilowatt-hour to 2.15 pounds and the total saving in coal thus effected, together with that resulting from railway electrification, is placed at fifty million tons.

The report is confined to statistical and technical studies and does not touch upon the legal and financial aspects, although these were considered by the committee. The original plan, it will be recalled, was to form a Superpower corporation, to the stock of which customer companies would subscribe; in other words, it would be a co-operative organization free from outside financial control. One of the objections raised against such a corporation was the lack of agreement in the laws of the various states and the rulings of the utility commissions. Moreover, some feared lest the system savor of too much Federal control. Whether this proposition will be carried out or whether the system will be built up simply by interconnection and agreements between the various utilities concerned is a matter of conjecture. There appears to be apprehension in some circles that a Superpower corporation which might buy and sell energy cheaper than it could be generated in many of the smaller plants, would render them obsolete and practically wipe out their investment. It is important, however, that a broad and unselfish view of the project be taken with a determination to conserve coal and money, considering the territory as a whole. And above all, now that the investigation has been completed, it is essential that the fullest use be made of the findings.

Steam Power from Blast-Furnace Gas

WASTE heat is a byproduct of industrial processes and may be contained in hot water, exhaust steam, gases at high temperatures and gases at medium temperatures that are combustible. It is in the last-named class that blast-furnace gas belongs. This gas has a temperature of from two hundred and twenty-five to five hundred and fifty degrees Fahrenheit and an average heat value of about ninety-four British thermal units. A six hundred-ton blast furnace under normal operation produces about 3,300,000 cubic feet of gas an hour, or the equivalent of about twenty-one tons of coal having a heat value of thirteen thousand British thermal units per pound. These figures clearly indicate the possible savings in fuel by utilizing blast-furnace gas for power purposes, and the losses that may occur when these gases are allowed to blow to the surrounding atmosphere.

In the past, cheap fuel combined with the difficulties of complete utilization of these gases led in many cases to a large portion of this gas being allowed to go to waste. Approximately thirty-five per cent of the gas given off is required for furnace operation, leaving sixty-five per cent for power purposes. If properly used the gas from a six hundred-ton furnace is capable of supplying thirty-five hundred kilowatts over and above the power required for the furnace and power-plant operation. Unless the furnace is connected with a steel mill, a market must be found for the power, which means selling it to other industries or to a utility company. To utilize this gas requires a large investment for a power plant and a trained personnel for its operation, which adds to the complication of operating the

furnace. This has led, where power could be purchased at reasonable rates, to allowing the gas to blow to the atmosphere and buying the power required for furnace operation. Furthermore, the amount of power required for the furnace is comparatively small. Under these conditions the wasting of this gas may be justifiable, but where the furnace is operated in conjunction with steel mills there are sound economic reasons for its complete utilization.

In this issue the leading article, "Steam Power from Blast-Furnace Gas," discusses the problems involved in the burning of blast-furnace gas under boilers. It is evident that the efficient burning of this gas has been a development of no small magnitude. The supply of gas fluctuates over wide ranges during the twenty-four hours' operation, consequently if full utilization is to be made, some means must be provided to equalize the supply of fuel to the power plant. The first thought would be to store the gas on the peak supply to be used at periods of minimum supply. However, the gas has a relatively low heat value, which makes storage not feasible on account of the large bulk per heat unit. This has led to equipping the boilers for coal firing during the periods of low gas, to more completely utilize the gas on the peak supply. To do this has required the development of special designs in gas burners, combustion chamber, baffling of the boiler, and various other refinements.

In the installations now in operation there are a number of different schemes in use. Undoubtedly, some of these serve the purpose more economically than others, and as experience is gained there will in all probability be a standardization of the methods of burning blast-furnace gas under boilers. However, we have gone far enough in this development to know how to use this gas economically, when a power load is available, therefore every effort should be made to stop another one of our national wastes.

Meters as an Incentive to Economy

IN MANY manufacturing establishments power has always been looked upon as a mere incident of the processes by means of which raw material is converted into finished product. There is keen supervision of all direct labor and material cost, but the power cost loses all identity as one of the ingredients of the mixture that goes by the name of burden or overhead. Even where precautions are taken to establish economical generation of steam and other energy, it is frequently the case that no attention is given to its efficient use. This may be attributed to a fault in general management, and in the small establishment improvement must be dependent upon more effective supervision from this source. In the larger enterprise, however, it would undoubtedly prove more satisfactory to make the responsibility that of the superintendent of the department.

Perhaps the most powerful influence that can be introduced to fix the responsibility in this manner is the installation of meters to measure and record the energy consumption of each department daily or monthly. With instruments properly distributed, it becomes possible to determine this with comparative accuracy; in the case of the electric meters, with high accuracy. Knowing the power consumption of a department for a given period, the production during the interval can be checked against it and deductions drawn as to the economy exercised.

The introduction of such a method would make it possible to hold each superintendent to strict accountability for the power used by his department. Supposedly, every competent superintendent is interested in promoting the welfare of the entire organization of which his department forms a unit, but he will only naturally be more concerned in making a good showing for his own management than for that of the concern as a whole. Having the welfare of the entire plant at heart, he might be expected to regulate his power consumption as carefully as his labor or material consumption. However, to do so in an unmetered plant, would cause no credit to accrue to him. Human nature being what it is, it must be granted that the conditions do not supply any great incentive to keep consumption down, and that one is likely to find the efforts concentrated on those elements of cost that more directly affect the individual showing made. However, when aware that the power employed is being measured and will be charged at the end of the accounting period, self interest will prompt a careful scrutiny of operating conditions that is likely to result in savings through the correction of wasteful practices. Motors are not likely to be allowed to run idle for considerable periods. Valves on steam-consuming devices will be closed when the apparatus is not in operation. Leaks and wastes of all kinds will be reduced to the minimum.

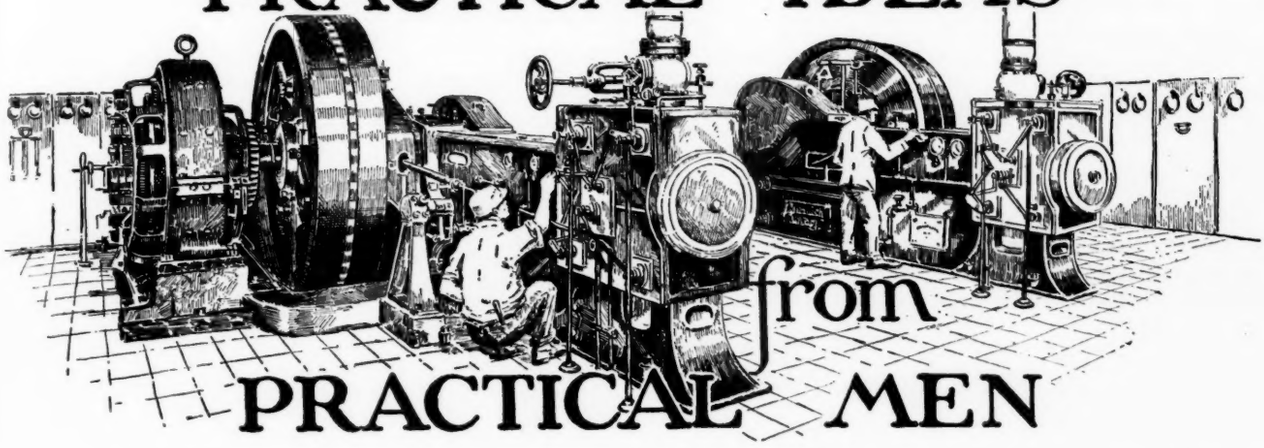
In a metered plant it is desirable, if possible, to establish a standard price per unit of power to be used, in order that the charge for power shall always vary in the same ratio as the number of units consumed. Such a method renders the power charge independent of the efficiency of the generating station and will undoubtedly be of advantage in comparing statements covering different periods.

In a telegram sent to the national conference of business-paper editors, recently held in Chicago, Secretary Hoover made the following statement: "We have, indeed, great problems yet to solve. We are dealing with questions of railways, farms, shops, and of instruments of commerce and industry, but in the background of every person's mind there is the fact that we are not dealing with mechanical things, but that we are concerned with the problems of men, women and children." There are few fields so technical as that of power, yet even here it is evident that all the buildings and equipment are in existence and operation solely because of, and for the sake of, human beings.

An instrument, when maintained in good working order, is not only useful, but may also be ornamental. But when it is allowed to remain out of order it is not useful, and if it ever was ornamental it will soon lose this characteristic also, by being neglected. No attendant wants to spend time and energy to keep a piece of equipment clean, in which sufficient interest is not taken by his superiors to see that the device is kept in working order.

The Geological Survey reports a disinclination on the part of some coal operators to furnish data in connection with unemployment to be compiled by the Department of Labor, on the ground that it will be the first of a series of requests for information which may follow. Let us hope that it will.

PRACTICAL IDEAS from PRACTICAL MEN



Light Versus Heavy Firing

When directions are given to us for firing boilers in the most economical way (assuming that only hand-fired boilers are meant), we are told to fire light and often. It is only natural to assume that the ideas of other engineers along this line agree with ours, but investigation shows that they do not, hence the question, What is light and what is heavy firing?

An expert fireman and satisfactory engineer took charge of a plant consisting of one boiler and one engine. His predecessor had fired this boiler as thousands are fired every day. A fire of soft coal ten or twelve inches thick was built and was replenished about once an hour with whatever was required to maintain this thickness. The new engineer carried a fire three inches thick and added two shovelfuls of coal about four times an hour. The result was a saving of one-quarter of the coal formerly used, with no change in the plant. Of course this added much to the work of firing that boiler, notwithstanding the reduction in the weight of coal used.

In another plant using one boiler, a mixture of hard-coal dust and soft coal was used with a fan to create the necessary draft. The fireman was not permitted to put in more than a shovelful at each time, but of course was actually firing about all the time. Result, a saving of $10 in 24 hours, due to low-priced coal and improved combustion. This furnace resembled an electric arc, and the fireman was paid extra wages on account of the strenuous labor required, but it was a good investment.

In my plant one man fires four boilers using a mixture of one part soft coal to four parts screenings. A steel snowshovel is always used for this service. I asked the fireman to put the amount of coal that he generally puts into a furnace, in a box, and it weighed 74 lb., including water used to moisten it. Each furnace contains 30 sq.ft. of grate surface, or 2½ lb. of coal per square foot for each firing period. I call this light firing, and we have plenty of steam with no smoke.

In the two cases first mentioned, the firemen would call my practice heavy firing. Where shall we locate the dividing line?

On the other hand, a writer on this subject earnestly recommends light firing and states that twelve shovelfuls is about right for good practice. In the absence of definite information it is fair to assume that a large scoop shovel is used, and that it holds 25 lb. of coal, or 300 lb. for each fire. If the furnace contains 49 sq.ft. grate surface, this means 6 lb. of coal per square foot, or 2½ times as much as I use, and still he calls it light firing. What does heavy firing mean?

This demonstrates that the only way to give intelligent directions for this service, also to make proper comparisons, is to give the weight of coal fired each time into a furnace of given size. This will enable us to determine the weight of coal used per square foot of grate surface.

It appears as if the practice maintained in my plant is about right, as it is not excessive, and at the same time does not make the fireman's position intolerable, as in the two first mentioned cases.

New Haven, Conn. W. H. WAKEMAN.

Valves in Water-Column Connections

Several instances have come up in my experience, when the value of valves on water-column connections has been forcibly demonstrated. In one plant, containing four hand-fired boilers which were not equipped with valves on the columns, a careless foreman caught a clinker hook in the ¾-in. water-column blow-down pipe of one boiler and broke it off short above the blow-down valve. As there was no means of shutting the water column off long enough to remove the broken nipple and insert another, the boiler had to come off the line at the very worst time of the day, and the long-continued blowing of steam and water so interfered with the firemen that they let the steam drop back enough to compel the pulling off of a part of the load for 15 or 20 minutes. To make matters worse, there was no other available boiler, and there ensued a struggle to hold steam and carry the load with the three remaining units. Needless to say, valves on the connections would have prevented this unpleasant experience.

In another plant, containing nine water-tube boilers, eight of which were continually fired with underfeed stokers, and hard pressed at that, to hold steam, from 7:30 a.m. to 10 p.m., each boiler being equipped with two water columns, there were no valves on the connections. One of the 1¼-in. pipes on one of the columns developed a bad-looking crack, and as there seemed to be a likelihood that the pipe would blow off the boiler, it was decided that the boiler would have to come off the line, in spite of the fact that it would mean pulling off a por-

tion of the load for several hours, until the steam could be reduced and repairs effected. The ninth boiler was out of commission for furnace repairs.

Being equipped with two water columns, it would have been a simple matter to shut off the defective column and make repairs at a more convenient time, and thereby save an embarrassing loss of part of the load. Incidentally, the entire nine boilers were later equipped with valves as rapidly as was practicable.

Of course some bonehead may close the valves and cause a burnt boiler; so also the blowoff valves may be opened and burn the boiler. I have known of that very thing happening. Still, no one would argue that there should be no blowoff valves on a boiler.

Memphis, Tenn. R. B. ARRELL.

Importance of Ground Wiring

Some time ago I took charge of a 25,000-volt switching and power substation. Transmission and distribution lines radiated in all directions, and the station had the name of being in a natural storm center. Breakdowns caused by lightning were frequent, armature coils in the generator would go to ground, necessitating costly repairs, and 25,000-volt busbar insulators and bushings would puncture. Current transformers back of the switchboard would break down at times. Taken altogether, it kept a repair gang busy during the summer months. As soon as possible a survey was made of all lightning arresters and ground wiring. They seemed to be in good condition.

The ground wiring was No. 0 for all main leads and No. 2 and No. 4 for branches. These wires were supported by porcelain knobs with tie wires. All branches were brought down at right angles and nicely soldered. Bends were made neat and square, and where the wiring passed steel girders or other conducting material, the insulation had been reinforced with circular loom and tape. Following the line on down, I found that it

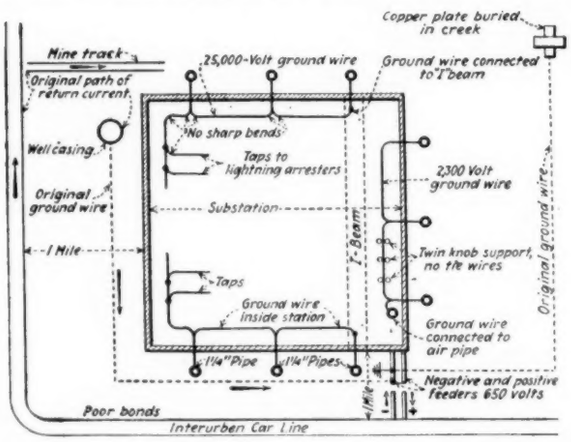
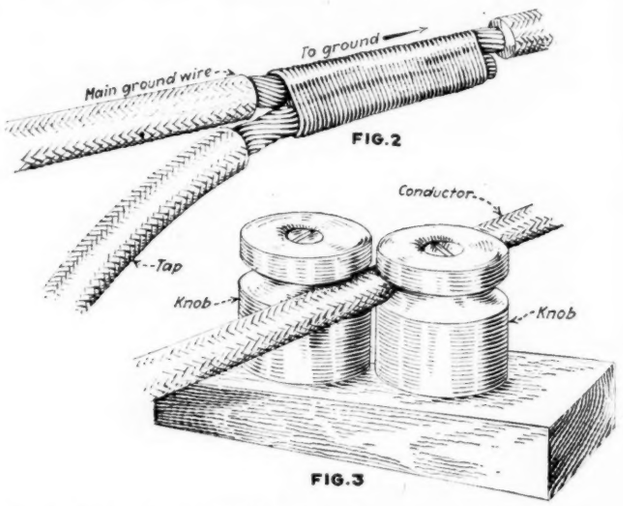


FIG. 1. GENERAL ARRANGEMENT OF GROUND CIRCUITS

led to a large copper plate buried in a small sulphur creek. However, the sulphur water had corroded the wire in two, so it was practically useless. Another ground lead had been connected to a well casing, as in Fig. 1, but I was informed it would burn off every little while. Another lead was run to the ground plate, buried in approved manner and connected to the generator through 1,000,000-circ.mil cable.

Several sections of 1¼-in. iron pipe 12 ft. long were obtained and driven to a depth of 10 ft. at different points around the station, as indicated in Fig. 1. Then in the most direct line possible new ground wires were run and no bends were made with less than a 24-in. radius. No rectangular bends were used where branch lines connected to the main leads. Binding wire was used at the joints, as in Fig. 2, and was sweated full of solder.

For supports the twin-knob method was used (Fig. 3), as this did away with the tie wires, and in my



FIGS. 2 AND 3. METHOD OF SPLICING AND SUPPORTING GROUND WIRES

opinion was the most important item of all, as the tie wires around the conductor have a strong tendency to choke back high-frequency currents. Whenever the wires passed a girder or water pipe within striking distance (12 in.), they were connected solid to the ground wire. The operator had instructions to pour a bucket of water over each ground pipe at frequent intervals so as to insure moist earth.

The next electrical storm that passed over proved that the right idea had been hit upon, as no damage was reported except that one lightning arrester had failed. This was repaired and put back in service and practically ended the trouble. Lightning arresters would occasionally burn up, but arcs from line conductors to grounded objects were a thing of the past.

The fact that the lead to the well casing would burn in two was a puzzler until it was discovered that the return to the direct-current generator was made through this connection and not through the ground provided for the current, on account of the trolley rails not being bonded. The return current took the path of least resistance back to the generator, which in this case was through the rails in a coal mine to a point near the well casing. The ground wire to the pump casing was not sufficiently large to carry the current, and burned off. Proper bonding of the rails cured this trouble.

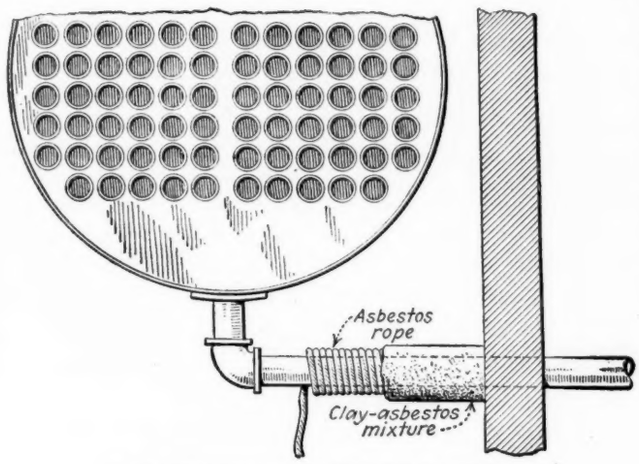
I have seen other installations where sections of the ground wires were in the form of a spiral. This is wrong, as one turn only will choke back high-frequency current to an astonishing degree. I have also seen ground wires from lightning arresters run to ground through an iron pipe or conduit. Even though the rules call for wire to be grounded on the conduit, I believe this practice is not correct for the best protection from lightning.

Straight leads, large-radius bends where necessary, no "dead ends" if possible, high-tension and low-tension arresters on separate ground circuits and no iron in the ground circuit will give a maximum of protection as regards ground wires. I have followed these rules in several installations and have been rewarded with a minimum of trouble. M. A. ANDERSON.

Pittsburgh, Pa.

Protection for Blowoff Pipe

A number of suggestions have been published from time to time for protecting blowoff pipes from the heat of the furnace. A cheap covering can be made by mixing



PROTECTING THE BLOWOFF PIPE

up a batch of fireclay and fine asbestos, and adding one pint of salt to each four gallons of the mixture. To apply, wind ¾-in. asbestos rope around the pipe and then plaster some of the mixture over it. Make the rope at least two thicknesses, and it is a certainty that the user will not be bothered with falling covering.

Portsmouth, Ont., Canada. JAMES E. NOBLE.

Care of Fuel-Oil Burners

Burners should be taken apart as completely as possible at regular intervals and thoroughly cleaned with kerosene or gasoline by means of a brush. All carbon should be scraped off the tips, or it will cause a streaky flame. Waste or cloth should not be used for cleaning burners, as lint and shreds will cause clogging of the outlets.

After the burners are assembled, they should be tested for leaks which may occur at the various joints. This test is best made with water, and is easily accomplished by making a connection with the feed pump by means of a flexible hose, to the burner. The water pressure used should be the same as the oil pressure in the system. If no leaks appear with the water, there will not be any oil leakage.

The most frequent cause of burners becoming clogged is by the oil carbonizing in the burner itself, although it is sometimes caused by foreign matters entering the burner, owing to improper straining. Whenever the burner becomes clogged, it should be cut out and blown through with steam. When burners are not in use, they should be coated lightly with lubricating oil to prevent rust, and should then be stored in a place free from dust.

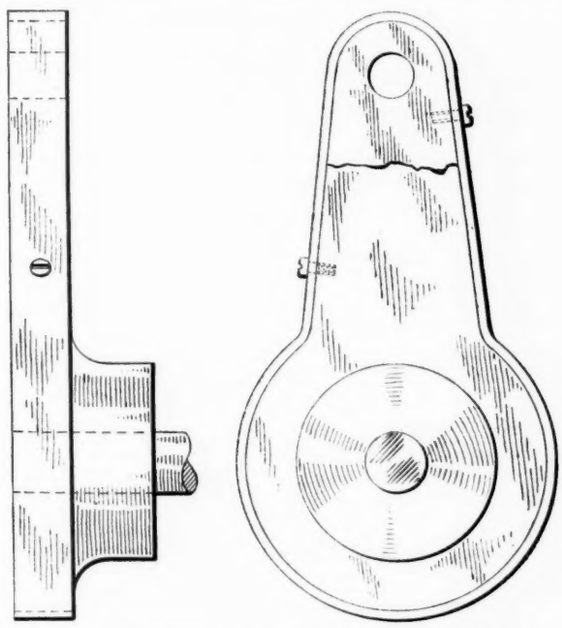
Most accidents in plants burning fuel oil result from careless handling and burning of the oil. The most common accidents are from flarebacks in the furnace, due to the accumulation of oil vapors caused by neglected leaks coming in contact with a naked flame, flash or spark of some kind. Flarebacks are the most frequent cause of explosion and should be carefully guarded against. These have usually occurred when lighting up, caused by the accumulation of oil vapors in the furnace from occasional leakage from the burner tip. The safety rules for preventing accidents in fuel-oil burning plants are as follows: Frequent inspection of the burners and piping system for leakage; do not allow any leakage of oil to continue at any point in the system or any spilled oil to accumulate. Wipe up immediately. It is good practice to blow steam or air through the furnace to drive out the oil vapors before lighting the burners

In lighting off the burner, stand at one side and light the burner by means of a torch at least four feet long, so that in case a flareback should occur, the chances for personal injury will be as slight as possible. Standing in front of the burner when lighting off should not be allowed. Never relight a burner from a hot furnace wall. Never leave a burner valve turned on. Should the flame be extinguished through some accident, close the valve immediately, otherwise there is danger of a flareback on relighting. H. BLOMGREN.

Brooklyn, N. Y.

A Valve-Crank Repair

The accompanying sketch shows how a repair was made to the crank of a Corliss exhaust valve that was broken along the line shown. A piece of strap steel



BAND SHRUNK ON BROKEN VALVE CRANK

was forged to fit around the crank, as shown, and it was then shrunk in place. To make doubly sure a small capscrew was threaded into each side of the crank. This enabled the engine to be used until a new crank could be secured from the builders, but it worked all right at that. J. P. LEROY.

Albany, N. Y.

CORRESPONDENCE

Lengthening and Shortening Corliss Governor Reach Rods

On page 574 of the Oct. 11 issue of *Power*, P. A. Upham tells of two engineers having an argument about shortening or lengthening Corliss-engine governor reach rods. In my estimation both are partly wrong and partly right.

Governor reach rods are for the purpose of equalizing the cutoff on both steam-inlet valves. Lengthening the long rod and shortening the short one will decrease the speed of the engine and governor, and the governor will operate on a lower plane than before the change was made, this with outside catch blocks.

New York City. PATRICK MOLLOY.

Replying to Mr. Upham's letter regarding changing the length of the governor reach rods, both engineers may be right in their view on the engine that each had in mind, and both wrong with regard to the engine the other had in mind. On some Corliss engines the opening and closing edge of the valve is on the inside near the center of the cylinder length, and on other Corliss engines the steam passes over the top of the valve and is admitted to the cylinder, past the outside edge, or cutoff edge, of the valve, in which case the movement of the governor reach rods to perform the same operation of tripping cam on the different engines would be in a directly opposite direction because the latches open the valves in opposite direction to admit steam.

On one engine it would shorten the point of cutoff and on the other it would lengthen it. In the case of lengthening the long rod and shortening the short rod, the speed of the engine and governor would be decreased with the same load and steam pressure.

Changing the length of the reach rods could be carried to such an extreme as to put the governor out of balance—that is, in a position where it could not rise high enough to set the cams in position to prevent excessive speed on the engine—in which case the engine would run away. In the other position the governor could not drop low enough to hold the valve open to the full throw of the eccentric, at the extreme travel of the eccentric, being tripped at the time when it was supposed to hook on and let go, in which case the engine would stop with a small load.

A governor is supposed to revolve at a given speed to maintain an equilibrium between the two extreme variations of full load and load. When these rods have been changed to such an extreme in lengthening the cutoff for the purpose of having the engine do more work without making any other changes, there is a possibility of putting the governor over its equilibrium and causing excessive speed.

Should it be desired to make a considerable change in the speed of an engine, it will be necessary to note the speed at which the governor is supposed to revolve, and to keep it at that speed. An increase in engine speed may require changing the size of the governor pulleys so that the governor can operate and set the cams for any point of cut without any material increase in speed, which is the purpose of all Corliss engine governors.

Cambridge, Mass. R. A. CULTRA.

Simplifying Engineering Formulas

A contributor to the correspondence columns of *Power* made an effort to simplify the subject of engineering formulas under the title of "Humanizing Engineering Formulas," on page 302 of the Aug. 23 issue. As so often happens, he fell into the error of using an elaborate explanation which proved, in my case at least, much more difficult to understand than the original problems given as examples.

Under the suggested method the puzzled student was directed to take a simple example, such as $(a + b)^2$, and then to consider how to prove that quantity equal to $a^2 + 2ab + b^2$. He was then to draw a diagram in which the letters a and b were to be represented by lines in such a way that the product of the letters would be represented by areas. This was slightly confusing, but by concentrating on the diagram it was possible to see how it was made, and what it stood for.

So much for a simple example, but when it came to the cube of $a + b$, the resulting diagram looked like a cubist's conception of the fourth dimension. It will be admitted, however, that it is difficult to remember formulas and to apply them intelligently unless one understands how to derive them, and so the question is, how can the derivation of a formula be visualized without tangling one's self up in complex analogies? I have always found it easier to do this by means of simple arithmetic.

It is a simple matter to multiply $a + b$ by itself to find the square, like this:

	$a + b$
	$a + b$
Multiplying by a:	$a^2 + ab$
Multiplying by b:	$ab + b^2$
Adding	$a^2 + 2ab + b^2$

Doesn't that show just how that formula is derived? And in the case of the cube of the quantity, it is just

about as simple, for we have only to take the square already found and multiply by $a + b$ again, thus:

$$\begin{array}{rl} & a^2 + 2ab + b^2 \\ & a + b \\ \hline \text{Multiplying by } a: & a^3 + 2a^2b + ab^2 \\ \text{Multiplying by } b: & \quad a^2b + 2ab^2 + b^3 \\ \hline \text{Adding:} & a^3 + 3a^2b + 3ab^2 + b^3 \end{array}$$

For $(a + b)(a - b)$ we have the same thing, but we must remember that a plus times a minus is minus, while like signs always make plus. Thus, $(+a)(-b) = -ab$, while either $(-a)(-b)$ or $(a)(b) = +ab$. Then, multiplying out $(a + b)(a - b)$, we have:

$$\begin{array}{l} a + b \\ a - b \\ \hline a^2 + ab \\ \quad - ab - b^2 \\ \hline a^2 \quad - b^2 \end{array}$$

To use the simplest and most natural way of working out a problem makes it easiest to understand. When we search too far for an analogy, we are likely to forget the problem itself in our effort to understand the analogy.

ALEXANDER BANCROFT.

Pittsburgh, Pa.

Estimating Steam Consumption of Bleeder Turbine

In connection with Joseph Gershberg's article, page 556 of the Oct. 11 issue of *Power*, on estimating the steam consumption of bleeder turbines, we are operating, a 1,000-kw. turbo-generator on saturated steam at 150 lb. gage, bleeding at 10 lb. and carrying 27 to 28 in. vacuum, depending on the amount of circulating water available, as this is used in process work.

Owing to reciprocating engines on the system we do not feel sure of the flow-meter measurements on account of the pulsating flow in the pipes, but as nearly as we can estimate from these and the quantity and temperature rise of the cooling water, the guarantee figures, which the builders state are based on exhaustive tests of an identical unit, are nearly correct.

It has been interesting, therefore, to figure up the corresponding values by Mr. Gershberg's method and these are tabulated herewith:

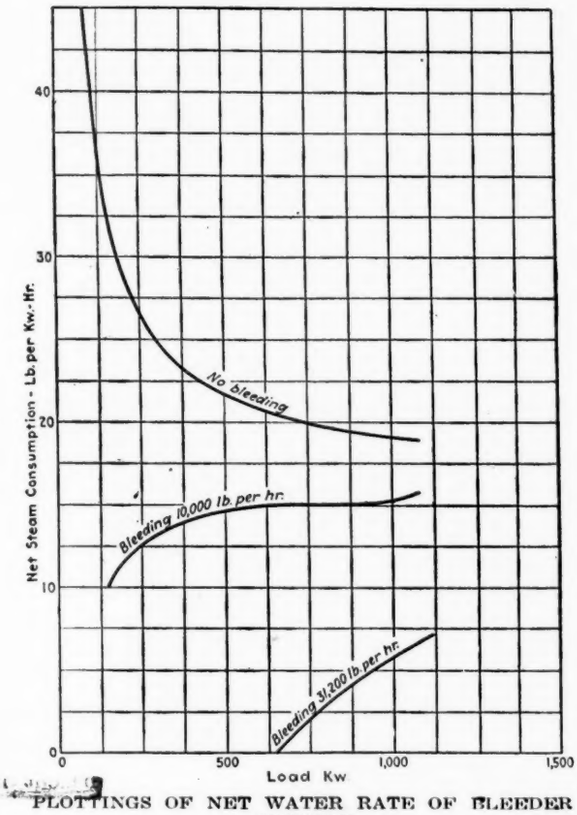
Load, Kw.	Steam Consumption, Lb. per Hr., No Bleeding	Steam Bled, Lb. per Hr.	Guaranteed Figures, Bleeding, Lb. per Hr.	Estimated by Mr. Gershberg's Method
250	*6,700	10,000	*13,000	12,800
500	10,950	10,000	17,350	17,540
750	14,860	10,000	21,200	21,400
1,000	19,100	10,000	25,300	26,880
750	14,860	31,200	*32,800	33,150
1,000	19,100	31,200	37,000	38,400

The values marked with an asterisk (*) are not given directly in the guarantees, but were obtained from Willans lines plotted from the other figures.

Considering the wide range of load and the amount of steam bled shown by these figures, the agreement of the results with those estimated by Mr. Gershberg's method is remarkably close, and any variations from final test results would probably be less than other unavoidable errors in estimating the conditions to be met.

A still more interesting and impressive showing of the advantage of a bleeder turbine is obtained by plotting the net water rate of the bleeder turbine—that is, pounds of steam per kilowatt-hour for steam actually rejected to the condenser—which shows that at the higher rates of bleeding the electrical power is obtained at practically no expenditure of steam, as shown by the accompanying curves.

Our only operating objection to the bleeder turbine is that, owing to the much wider range of valve travel required to handle bleeder steam, the speed varies somewhat more than where no steam is bled.



PLOTTINGS OF NET WATER RATE OF BLEEDER TURBINE

New Haven, Conn. A. D. FISHER.

Emptying Barrels with Compressed Air

Regarding the question of emptying oil barrels by compressed air, we guard against excessive pressure by using a section of small hose between the air supply and the barrel, slipping it loosely on the ends of the pipes so that it will be blown off at a low pressure. Iron barrels that will withstand considerable pressure are coming into general use.

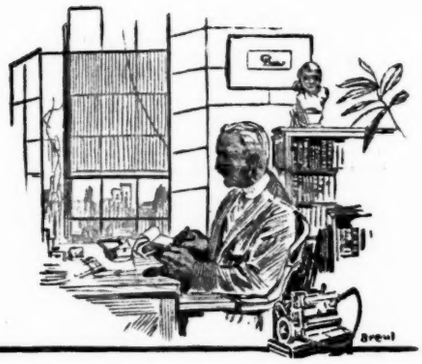
We distribute oil to the tanks in the various departments through a system of piping, using a small steam pump set at a sufficient elevation so that we can drop the suction pipe into a barrel and empty it in a few minutes. Where this does not apply, the compressed-air method is used.

J. O. BENEFIEL.

Anderson, Ind.

A recent application for a preliminary permit from the Federal Power Commission provides for the construction of a 100-ft. dam and a power house on Aarons Creek on the mainland east of Wrangel Island. The installed capacity would be 12,500 hp., and the power would be used in the manufacture of pulp and paper. J. G. Galvin, 620 Alaska Bldg., Seattle, Wash., is the applicant.

QUESTIONS AND ANSWERS



Regulate Draft with Uptake Damper

Is it considered good practice to regulate the draft of a boiler by the ashpit doors? J. L. F.

It is not good practice. The draft should be regulated by adjustment of the uptake damper. Regulation of draft by the ashpit doors shuts off the air supply through the fuel bed and the ashes on the grate, and the grate bars become heated, resulting in clinker and warped grates. With the damper open and the ashpit doors wholly or partly closed, the draft in the setting is increased, and air is drawn into the furnace and all parts of the setting, through the doors and cracks, out of proportion to the coal burned. By closing the breeching damper, all such air leaks are reduced in proportion; whereas, by closing the ashpit doors to reduce the air supply through the fuel bed, the supply from all other sources is increased.

Benefit of Water in Ashpit

What saving of coal is there and what benefit is derived from keeping the ashpit of a boiler furnace covered with water, and does it not tend to produce clinker in the fire? J. L. F.

It cannot be stated generally what saving of coal may result from keeping an ashpit full of water. The ability to save arises from the fact that steam introduced to the aspit, or present from evaporation of water placed in the ashpit, causes the fire to burn with less clinkering of the coal and thereby coal which has a tendency to clinker may be used to better advantage. The percentage of improvement of economy depends, of course, on the particular coal used, and the amount of clinkering when there is no steam or water in the ash pit.

Water in an ashpit does *not* tend to cause clinkers, but on the other hand tends to prevent clinkers, thereby helping to keep the fire open and allow admission of air for more perfect combustion of the coal.

Reduction of Baumé-Temperature Readings to Standard Conditions

When taking hydrometer readings for the strength of calcium-chloride brine, is there any method of computing or correcting the reading taken at the temperature carried to reduce the readings to standard conditions; for instance, with a reading of 19 deg. Baumé at 14 deg. F., what would it be for the same brine at the temperature of 60 deg. F.? W. M. H.

Allowance must be made for the variation of density of the liquid from the density it would have at the standard temperature. There is not an absolutely uniform coefficient of expansion for different percentages of the chloride present or for different temperatures, but for most practical purposes it is sufficient to assume that calcium-chloride solutions in water have a cubical expansion or contraction equal to 0.00028 of their volume per degree F. change of temperature. For example, if the reading is to be reduced to 60 deg. F. as a standard, then the specific gravity at 14 deg. F. would be $1 + (60 - 14) \times 0.00028) = 1 + (46 \times 0.00028) = 1.01588$ times as much as at 60 deg. F. If the hydrometer reading for 14 deg. F. was 19 deg. Baumé, then from a table giving Baumé degree equivalents in specific gravities for liquids heavier than water, it may be seen that 19 deg. Baumé = 1.151 specific gravity, or by calculation, $145 \div (145 - 19) = 1.151$ sp.g.; and if this is reduced to specific gravity at 60 deg. F., we would have $1.151 \div 1.01588 = 1.133$ as the specific gravity at the standard temperature. Then upon referring to a table of Baumé and specific gravity equivalents find that 1.133 sp.g. = 17 deg. Baumé, or by calculation $145 - \frac{145}{1.133} = 17.03$ deg. Baumé.

Thickness Required for Boiler Shell

What thickness of 55,000-lb. tensile strength steel would be required for the shell of a boiler 72 in. in diameter, to carry a safe working pressure of 138 lb. with a factor of safety of 4.5? L. V.

The required thickness of plate would depend on the strength of the weakest course, computed from the efficiency of the longitudinal joint, as well as the tensile strength of material, diameter of shell, working pressure and factor of safety. The working stress per inch length of the longitudinal joint would be $72 \times 138 \div 2 = 4{,}968$ lb. If the efficiency of the joint is, say 80 per cent, then with 55,000 lb. tensile strength of material and a factor of safety of 4.5 the allowable stress per inch length of shell for material one inch thick would be 80 per cent of $55{,}000 \div 4.5 = 9{,}777$ lb. For the working stress of 4,968 lb. the required thickness of material would be $\frac{4{,}968}{9{,}777}$ in. = 0.508, or practically $\frac{1}{2}$ in.

Setting Valves of Automatic Buckeye Engine

What is the method of setting the valves of a Buckeye engine with riding cutoff operated by a shaft governor? J. J. M.

Remove the valve covers so the valves may be seen or felt by means of a long piece of flat wire. It is to be borne in mind that the exhaust is from the ends of the main valve and that it takes steam from the center, so that when opening, the valve is traveling in direction opposite to the piston; also that there is an indirect motion of the rocker from the riding eccentric for

movement of the cutoff valve. Adjust the travel of the rocker arm so it swings equally each side of a plumb-line. This may be found by revolving the main eccentric on the shaft. Adjustment to correct inequality is made at the eccentric rod. The main valve is then squared by placing the main eccentric at its greatest throw forward and noting if there is a full port opening, then putting the eccentric on its opposite center and noting if there is full port opening, adjusting the rod length so the valve will be opened the same amount with the eccentric on first one center and then the other. Any adjustment thus needed of valve-rod length is made by slipping the clamp on the valve rod where connection is made from the rocker arm to valve stem. The engine is then put on dead center and the main eccentric revolved in the proper direction following the crank until the desired lead is obtained on that end. Turning upon opposite center, the lead should be the same. If not, equalize at clamp on the valve rod. The lead to be given varies from $\frac{1}{16}$ in. for a 10-in. cylinder to $\frac{1}{4}$ in. for a 24-in. cylinder, increasing this $\frac{1}{16}$ in., for high-speed engines.

To set the cutoff valve, the rider eccentric and main eccentric are placed together and the cutoff valve should then rest square over the ports. Placing the engine on the dead center, the governor wheel should be revolved on the shaft until the throw of the eccentric is exactly in line with the crank on account of the reverse motion of the indirect rocker. Secure the governor wheel in that position. Block out the governor half way, turn the engine over slowly and note when the valve is just closed on the end taking steam. Mark this distance the crosshead has traveled on the guides. Turn the engine over on opposite center and note when the valve closes on that end. If not alike, find the difference between the two cutoffs and put the crosshead at a point representing one-half this difference and reset the cutoff valve until it closes at that end. It will then be found correct for the other end.

Calculations for Refrigerating Capacity

What formula is used to obtain the following data in a refrigerating plant. (1) Volume of gas in cubic feet; (2) diameter of compressor cylinder; (3) capacity of double acting compressor? J. G. S.

Taking up question one, the volume V of gas in cubic feet which must be handled per minute to deliver one ton of refrigeration is obtained by using the formula,

$$V = \frac{200 \times v}{H - h}$$

where H is the total heat in a pound of ammonia at the suction pressure, and h is the heat in a pound of liquid ammonia at the receiver pressure. Both these may be obtained from the tables of the properties of ammonia, published in *Power*, page 96, Jan. 18, 1921. The volume v of one pound of ammonia vapor at suction pressure is also to be found in the tables. The value 200 is the number of heat units representing one ton of refrigeration per minute. This is on the assumption that the suction vapor at the compressor is dry saturated (the suction elbow should be frosted).

As example, suppose the suction pressure is 30 lb. gage, with a receiver pressure of 150 lb. gage. The total heat in a pound of dry ammonia vapor at 30 lb. gage (45 lb. absolute) is 617 B.t.u. The heat of the liquid h, in one pound of liquid ammonia at 150 lb. gage, is 137 B.t.u., and the volume of one pound of vapor at 30 lb. gage is 6.29 cu.ft. The formula is then written

$$V = \frac{200}{617 - 137} \times 6.29 = 2.62 \text{ } \textit{cu.ft. per minute per ton}$$

The volume in the compressor cylinder displaced by the piston is likewise 2.62 cu.ft. per ton. Because of leakage the gas delivered is only about 75 per cent of the cylinder volume. The value of $2.62 \div 75 = 3.47$ is the actual piston displacement required per minute per ton. Knowing the compressor speed and the tonnage required, the cylinder volume per stroke can be found.

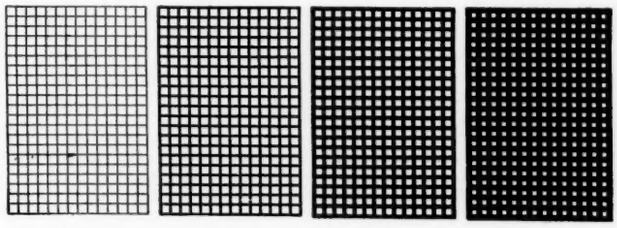
If the tonnage per minute is found as indicated, the tonnage per twenty-four hours is the same. This is for the reason that a ton of frigeration is removal of 200 B.t.u. per minute, or 288,000 B.t.u. per 24 hours, which is equal to the refrigerating duty secured by the melting of 2,000 lb. of ice, each pound of which takes up 144 B.t.u. in melting, or 288,000 B.t.u. per ton.

The capacity of double-acting compressors is based on the actual displacement of the piston multiplied by a factor ranging from 60 to 80 per cent. At high speed the factor ranges close to 60 per cent.

Ringelmann Smoke Chart

What is the Ringelmann Smoke Chart and how is it used for classifying observations of smoke given off by chimneys? J. C.

Ringelmann's smoke chart consists of four cards ruled with vertical and horizontal lines, forming squares. No. 1 is ruled with lines 1 mm. (0.03937 in.) thick and spaces 9 mm. (0.35433 in.) wide. No. 2 is ruled with 2.3 mm. (0.09055 in.) lines, the spaces being 7.7 mm. (0.30315 in.). No. 3 is ruled with 3.7 mm. (0.14567 in.) lines, the spaces being 6.3 mm. (0.24803 in.) wide.



No. 1 No. 2 No. 3 No. 4
RINGELMANN SMOKE CHART (MUCH REDUCED SCALE)

The chart, as published by the United States Geological Survey and used by the smoke departments of a number of cities, consists essentially of a folder 12 x 26 in. over all. The four cards are printed on this folder, each card, consisting of 294 squares, or 14 squares wide by 21 squares in length, as shown in the illustration at a greatly reduced scale. The cards thus ruled are placed about 50 ft. from the observer in line with the chimney top emitting smoke. Some observers also place alongside of the ruled cards a white card and one that is a solid black. At a distance of 50 ft. from the observer the lines become invisible and the ruled cards appear to be of different shades of gray, ranging from very light gray to almost black. The observer glances rapidly from the chimney top to the cards and judges which one corresponds with the color and density of the smoke.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Theory of Lubrication*

By William F. Parish

A lubricant has two functions to perform: First, keeping the surfaces apart; second, conveying from such surfaces heat that is caused by friction. Friction comes from two sources: First, abrasion or the metal striking due to the use of too thin an oil, which is called solid friction; and second, the oil working on itself, which is called fluid or internal friction. The art of lubrication is based on the balancing of these factors so as to secure for every possible classification of machinery a lubricant that will keep the surfaces apart at working temperatures and at the same time cause the least internal or fluid friction.

A difference can be noticed in the operation of machinery when lubricated with materials so heavy that they produce internal friction and when lubricated with materials that are properly balanced so that there is no abrasive friction and the oil operates with a minimum of fluid friction.

Loss Due to Resistance of Oil Films

Loss of power when using a heavy oil is due to the resistance of the oil films. The oil between the surfaces can be considered as a series of films. That which is next to the fixed bearing will drag slowly against the fixed surface of the lining. The drag is related to the adhesive power of the oil; oil that is high in adhesive qualities will drag slower than oil that is not so adhesive. The film that is next to the shaft, at whatever speed it revolves, will be dragging at nearly the surface speed of the shaft, affected also by the power of adhesion—the greater the adhesion the faster it will drag. The layers in between these two films revolve at different speeds; one revolving at comparatively high speed, the other almost still. The effect of this working of the oil films is transferred to heat. The greater the resistance in the oil due to its cohesion or power of clinging together between the surfaces of the various films, naturally the greater the heat developed. This heat is radiated through the bearing and through the air. The conductivity of the metal, therefore, has much to do with the temperature at which the oil is finally maintained.

Every oil requires a certain amount of time (generally from 45 minutes to 1½ hours) to work up to a temperature above that of the room, which is maintained for the rest of the day. The oil, when cold, may be of the proper body to keep the surfaces apart and operate efficiently. However, the heat generated within the oil itself through fluid friction due to constant operation may be sufficient to lower the viscosity or reduce the body of the oil to a point where abrasion takes place. The heat of abrasion will still further increase the temperature of the oil and reduce its effectiveness as an agent for keeping the surfaces apart. It is necessary, therefore, to use oil that will maintain the prescribed body at working temperatures and under the highest surrounding temperatures to which the machinery is subjected. This makes it necessary to use an oil that, when cold, has too much body for effective lubrication, but this oil will generate enough heat in starting to reduce its body so that the balance is obtained.

Oil Requirements of Bearings

Thin bearings that radiate heat quickly require a different oil from bearings designed so that the heat is radiated slowly, allowing the oil to work at higher temperatures. In the latter case, which is generally the rule with the heavier bearings, an oil of considerably greater viscosity must be used originally to compensate for the difference of radiation. The power required to start the shafting when the oil is cold is always excessive, and the power is reduced as the oil heats up. When the heat generated equals the heat radiated, the body of the oil becomes steady and the power required for the operation is likewise steady.

In the case of spindles or light high-speed machinery sensitive to lubrication, the effects of improved lubrication are always denoted by three conditions: First, reduction in power; second, reduction in temperature; third, increase in speed.

The cotton spindle, which for certain classes of work revolves at from 800 to 12,000 r.p.m. is the lightest type of general machinery to lubricate. The oil made for the cotton spindles is the lightest-bodied oil made for lubricating purposes. The basic rules of lubrication which are worked out and studied in connection with the many hundreds of tests on these spinning frames, are applicable to every classification of machinery. Reduction in temperature through change of lubricant is always associated with reduction in resistance to the turning of machinery, even though at all times the speed is not affected. In general, in textile-mill lubrication-engineering practice, reduction in resistance in the spindle bases, with consequent increase of speed of the spindles due to the lessened band slippage and reduction in resistance of all the other machinery, will generally show in an actual increase in speed and production of the entire mill. In extreme cases with overloaded engines, the lightening up of the mill through reduction of the frictional loss will result in an increased number of revolutions per minute of the engine and will allow of operating at 10 to 15 per cent less power. Increased production as high as 1½ per cent has been secured with reductions of 10 to 12 per cent in the power necessary to drive the mill.

In straight mechanical-engineering practice, increasing the speed of the mill to secure greater productiveness must always be accompanied by forced increase of power. Forcing machines to operate at higher speed by changing the size of the pulleys or even by putting dressing on belts so that they will have greater traction always places an extra load on the main engine. In lubrication engineering, however, which is a science of reducing friction losses, the savings are all made up of reductions of losses of friction and resistance and of the loss or slippage in belt transmission system.

Illustrating an extreme case of friction losses, a test on a 10,000-hp. reversing rolling-mill engine is cited. It is only necessary to say here that lubrication of this large unit as found was representative of the conditions which existed in steel-mill practice some years ago and, unfortunately, is sometimes found today. Changing the manner and method of lubrication made it possible to reduce the friction load at 88 r.p.m. from 1,239.5 i.hp. to 249.95 i.hp., a reduction of practically 80 per cent.

Analyses of Tests

Analyzing the tests containing these figures showed that the original method of lubricating this unit gave results that approached the laws of solid friction; that is, that while the surfaces apparently were not actually in contact, there was interspersed between them material of such a heavy nature that the resistance was so great as to approach the resistance of solid masses working upon themselves. As soon as the lubrication was changed, the condition approached that which is given by consideration of the laws of fluid friction. It is, of course, impossible to secure in a unit of this kind either purely solid friction or perfect fluid friction. This test, however, indicates quite clearly a possible near approach to each of these conditions and represents what takes place in an extreme degree when lubricants are used that are entirely unsuited. In this particular case the great resistance in the engine itself was reflected in the difficulty of handling the reversing levers. The reversing was done by auxiliary steam cylinders as well as by hand levers. It required a full opening of the throttle to the auxiliary cylinder and all the power possible for one man to exert on the hand levers. After the change in lubrication was made, only partial opening of the throttle to the auxiliary cylinders was necessary, and the men would operate the hand levers with ease. Further, it was observed by the operators that the speed of the entire mill was increased. The engine was handled quickly on the reverse and would get up speed in a fraction of the time that was formerly required.

In this case all of the various rules shown in lubrication of spindles applied, as far as general lubrication was concerned. The lubrication of the steam cylinders, however, was handled through a new set of factors. The change which was made and the results obtained in reducing the load of this part of the unit were due to securing a better distribution of the lubricant through having it properly atomized and carried with the steam where it could be spread upon all the surfaces with which the steam came in contact, where formerly large quantities of a heavy lubricant not suited for the work were forced on the surfaces some seconds after the machine was placed in motion and this oil would be worked back and forth on these surfaces in that form, resulting in much fluid friction. The oil fed in this manner would not spread to the upper part of the cylinders, which were undoubtedly, in consequence, operating metal-to-metal. Of the total 990 hp. saved in this unit when it was turned 88 r.p.m., at least 50 per cent would easily be charged to cylinder and valve lubrication, the remainder to the main bearings, pins, guides and connections.

*Excerpts from paper presented at first annual convention of the American Society of Lubrication Engineers, Chicago, Oct. 13, 1921.

The Limitations of Silent Chain Drives*

By G. F. Anderson

Chain used on wheels or sprockets for power transmission is no doubt one of the oldest of mechanical contrivances, but the use of the "silent" chain for large and high-speed power transmission is hardly a quarter of a century old. For some years this drive was known to the general engineering public as a means of transmission to be used only under conditions decidedly unfavorable to belts, gears or ropes. While such is now sometimes the reason for chain installations, the silent chain drive has gradually won on its merits till it is now generally considered by competent engineers as a standard drive for practically all of the ordinary power transmissions between parallel shafts.

As to reliability, it may be stated that the breakdown of silent chain drives is not sudden unless a crowbar or similar husky object gets into the drive. If the drive is abused by overloading or overspeeding, the breaking down is gradual and will always give ample warning of final giving out to allow time for necessary repairs. The wear in the chain or the increase in chain pitch is manifested by the chain riding higher and higher on the sprocket teeth. This should of course, be observed occasionally and the chain should be repinned with oversized pins before it rides over the sprocket teeth. Repinning with oversize pins compensates for the wear in the links and brings the chain back to normal pitch. The wear on the sprocket teeth is negligible, as the chain pressure is distributed over the large number of teeth engaged. Silent chain drive should, of course, have proper attention, but this is less than is required by any other means of transmission, and it will stand more abuse than any other form.

The remarkably high efficiency of chain drive is well known, and a peculiar thing about it is that the efficiency does not decrease as the chain wears, but maintains its high mark of 98.6 per cent to the point of breakdown.

Where atmospheric conditions are bad, due to dust, steam, moisture or acid fumes, chain drives are reliable and efficient, as the power will be actually transmitted until the chain requires repairs.

It must be conceded that the silent chain drive has its limitations, and none know this better than the designers; for they are daily asked to supply drives that are outside the proper field of chain drive.

Sometimes the designers stretch the limits when it seems that nothing else will do or when a customer is willing to sacrifice quietness for other desirable features. Noise is usually the result of overspeeding. There are pretty definite maximum rotative speeds for each pitch of chain. When these are exceeded, the drives are noisy.

There is also a limit to the width of a strand of chain. Good practice would make the width not less than 1.5 multiplied by the pitch and not more than 10 multiplied by the pitch, although these limits are sometimes exceeded with entire success.

Chain velocity may be as high as 5,000 ft. per min. It is not the velocity that bothers, it is the rotative speed. The wear occurs on the small sprocket. Five thousand feet on a small sprocket, say 15 to 40 teeth, is utterly prohibitive, but on a large sprocket, say from 50 to 100 teeth, it might be permissible.

As to speed ratio, good practice holds to about 6 to 1 as maximum for large powers and 8 to 1 maximum for small power drives. The limitation on this is merely a matter of tooth contact—the more sprocket teeth in contact with the chain the less is the allowable wear on the joint before the chain climbs over the top of the sprocket teeth. For speed ratios greater than those given, slower-speed motors or double-reduction is often undesirable, but there are a large number of them used.

Some engineers have thought that chain drives should be used only on steady loads, but they are successfully applied to practically every kind of load. For a rhythmic uneven load such as a compressor, a spring compensating sprocket may be used if the flywheel does not provide sufficiently uniform rotation to prevent a whipping action of the chain. These sprockets have been used in sizes up to 300 hp. with entire success. It is better, however, and oftentimes cheaper, to provide sufficient flywheel.

For occasional shock loads the shearing pin sprocket is used. Here the pins connecting the rim to the hub shear on predetermined load and the rim spins around on the hub, thus protecting not only the chain, but the driver (engine or motor) and the driven unit. New pins are quickly and easily inserted and the drive again started. Many expensive shutdowns have been prevented by these sprockets when machines become clogged.

Maintenance cost is that of new pins for the chain. This amounts to approximately 20 per cent of the cost of the new chain, which is very low, inasmuch as the life of the repinned chain should be at least 75 per cent of that of the new chain. Sprockets usually outlast three chains or one chain twice repaired. The sprocket wear is small because each tooth engaged with the chain takes its proportional share of the chain pull, therefore the single sprocket-tooth bearing pressure is very low on large sprockets, which are cast iron, and on small sprockets, which are steel, case-hardened.

Sprockets under 29 teeth are made of medium carbon steel and casehardened. Large sprockets are made of semi-steel or cast iron. Chain links are made of special alloy steel and heat-treated to give the required toughness. The pins are high nickel steel and casehardened.

The round pin chains require oil lubrication, whereas the rocker joint chain is better lubricated with grease. Oil lubrication is best accomplished by running the chain in a bath of oil, which requires an oiltight case. Grease lubrication requires no guard except to catch that which may be thrown off at the sprockets.

*Extracted from an address delivered before the American Chemical Society, New York City, Sept. 16, 1921.

Southern California Edison Company Begins Work on New Plant

The California Railroad Commission has authorized the Southern California Co., of Los Angeles, Cal., to construct an additional plant in its Big Creek hydro-electric development, to be known as Big Creek No. 3 power house, which it is planned will have a capacity of 150,000 kw. Two generating units of approximately 25,000 kw. each will be installed as the initial undertaking.

A forebay reservoir will be created by a diversion dam on the main San Joaquin River, diverting the waters to the power-house intake through a tunnel 23 ft. in diameter and approximately six miles in length. Huntington Lake and Shaver Lake in addition to the main San Joaquin River are now available to the site of this power house, while the ultimate supply will be 500,000 acre-feet, at approximately 7,000 ft. elevation and 825 ft. effective head at the turbines. This enormous supply of water available for power purposes throughout the entire year will come from the combined capacity of Huntington Lake, Shaver Lake and San Joaquin River, with the system of reservoirs to be constructed for conserving and delivering the waters of Florence Lake, Blaney Meadows and Vermilion, Granite, Jackass and Chiquita Creeks.

One million barrels of fuel oil, the consumption of steam plants necessary to produce the equivalent amount of electrical energy, will be saved by an output from this power house of 200,000,000 kw.-hr. in 1923.

Less than five mills per kilowatt-hour is the estimated cost of production of electric current by the initial development. This cost will be reduced by the ultimate development to slightly in excess of two mills, as compared with an average cost of seven mills per kilowatt-hour for steam-generated current.

The first unit is planned for completion in April, 1923, and the second unit in July of the same year. An expenditure of $11,500,00 will be required up to that time. The cost of the complete development is placed at $17,500,000. This year 92,000 hp. of new hydro-electric power has been brought into service by the Southern California Edison Co. on Big Creek, the San Joaquin and Kern Rivers, and the company now has a force of 2,500 men driving the new project to a successful conclusion.

Business Papers Must Spread the Gospel of Work

That the American business press must drive home the present need for hard work and optimism and must practice as well as preach the gospel of work is the keynote of a speech made by James H. McGraw, president of the McGraw-Hill Co., Inc., at the recent Chicago convention of the Associated Business Papers, Inc. At this convention Mr. McGraw became the new president of the association. The following paragraphs are some especially striking and significant excerpts from his speech:

There are two great classes in the world today—those who look on the world in chaos and see no hope for the future, and those to whom the world disaster is but an inspiration for greater effort. I am putting the business papers in the latter class.

Business is stagnant, yet the dallying Congress, imitating Nero, plays the fiddle of back-home politics while business goes to pot. The tax bill languishes on Capitol Hill. The tariff measure, universally condemned, has been shelved, casting just so much added doubt upon the business future. The railroad refunding bill makes no progress. All that could stabilize business and restore confidence is neglected, despite the urgings of an administration that displays a gratifying amount of business sense.

Such are some of the features of a world situation unprecedented in complexity, in difficulties and in the number of discouraging features.

Each and every one of the situations referred to has a present-day bearing on American business. What is more, some of them will determine how America is to do business for many years in the future. If American business is to function up to the new position that has come to it during the war, and that necessarily flows from the fact that the center of world finance and of world influence has shifted to our shores, these governing conditions must be interpreted in terms of their influence on every industry. We may become, if we have but the knowledge, the foresight and the energy, what England has long been—the market center of the world. But we can take this position only if we have a race of business men equal to the occasion—a race worthy of a world-wide commercial dynasty.

We are appalled when our attention is called to criminal wastes of life through accidents and negligence, the prodigal waste of our natural resources through underdevelopment or political chicanery, the prodigious waste of materials through mismanagement and inefficiency. But of all the wastes that affect our happiness and prosperity, the waste of time and human effort is the greatest and has the most damaging influence.

If the business papers collectively and individually can instill into the minds of the thinking men of industry the gospel of intelligent work, we will have performed a tremendous service.

I am fully mindful that while I am urging this wider service, we ourselves are under fire from American business. Prices are falling in many lines, and American business demands that we, too, reduce prices, reduce our advertising rates. This demand, we business publishers know, is not justified. Business papers did not profiteer nor did they raise rates during the war in proportion to their increased costs. By rigid economies and reduction of profits they held off their rate increases until their properties went into red ink or the certainty of red ink was just ahead. Then much belated, our rates were moderately increased, but those increases were small compared with the increases on other products. Meanwhile, the standards of our service to the American business had been constantly raised. The war has forced us all to higher journalistic levels, and today the services that we are rendering our industries are incomparably greater than they were before the war.

It is to be hoped that our mechanical costs of production will be lowered and we shall receive more per dollar for printers' wages but, even should those decreases come, the larger margin that would thereby be left between gross revenue and operating expenses is sorely needed right now to bring the business papers to a level equal to the great opportunity for service which I have tried to picture. With all business papers raised to a proper plane, we would return to American industry a hundred-fold whatever margin may come to us between gross revenue and the hoped-for reduced operating costs. In other words, the added revenue will not go to dividends, but into better service to readers and advertisers.

In conclusion, let me say, we must consecrate ourselves to giving a full measure of the best service we have within us. As a nation and as publishers, we must quit our petty quarrels and arguments and devote ourselves to the tasks that lie before us. We had to fight and destroy to win the war. We will have to work and build to win the peace. The first nation that gets hold of the idea that the only salvation comes from work will come out on top and really win the peace.

Coal Storage Purely a Commercial Question, Says Dr. Bain

That the question of whether or not it is wise to store coal to eliminate seasonal shortage is entirely a financial one and that the technical problems involved are readily met, is emphasized in a recent statement from Dr. H. Foster Bain, director of the Bureau of Mines. Excerpts from his statement follow:

The adoption of a general policy that would provide reservoirs of bituminous coal to be drawn upon in times of great demand or of low production is entirely a commercial question. If the producer, or the dealer, or the large consumer, could produce or buy coal in the spring or summer for a price low enough to justify the cost of putting coal in storage and its rehandling, minus a fair insurance rate that he would be guaranteed a continuous supply in time of need, storage would become common.

This lower seasonal price of coal could be brought about by concessions on the part of the miner, the mine operator and the railroads. For the sake of obtaining more regular employment, the miner might accept a lower wage or rate in certain seasons of the year, although this is doubtful; but the mine operator might accept less profit during the same periods in order to keep up his production. Steady and regular mine operation at capacity production always means lower production costs, as compared with intermittent operation and lessened production. Overhead expenses —taxes, interest, management, together with the expense of keeping the mine in proper working condition—all go on, whether production is light, heavy or has entirely stopped. The railroads could assist by accepting a lower freight rate on coal moved in the spring and summer.

The small individual consumer, especially in the cities, often has inadequate storage space. Storage at the mine may allow a steady working day in time of shortage of cars, but will not insure steady seasonal operation. Again, large-scale storage at the mines does not do away with the difficulty of transportation often experienced to the points of consumption. Moreover, a great many mines are in a hilly or mountainous country, where but little if any space is available for large storage capacities. The proper place, therefore, for storage on a large scale is at or near points of consumption.

This latter kind of storage involves the use of a large plot of ground, as coal stored ten feet high allows slightly less than 10,000 tons storage per acre. The purchase and installation of mechanical coal-handling devices and systems would also be necessary.

When, at such a projected storage plant or yard, coal can be purchased at a delivered price sufficiently low to secure a fair return on the investment, after adding the operating costs of storage and rehandling, then coal-storage yards will become established near all of the points of heavy consumption and the present seasonal variations will be largely avoided.

There are no mysterious or unsolvable technical or mechanical questions that block the way to the adoption of a general policy of storing bituminous coal, in either large or small quantities.

A preliminary permit from the Federal Power Commission has been obtained by the Columbia (S. C.) Railway and Navigation Co., providing for investigation into the practicability of building a 24-mile navigable canal from the Santee River to the headwaters of the Cooper River. The company plans to put up a water-power plant at the southern end of the canal, with a head of 30 ft. and a continuous capacity of 4,000 hp.

Seekers after knowledge are respectfully referred to an article on "Application of Law of Kinematic Similitude to the Surge-Chamber Problem," in the October journal of the A. S. M. E.

News in the Field of Power

A. S. M. E. Council Makes New Appointments

At the first meeting of the season, on Oct. 10, the Council of the American Society of Mechanical Engineers approved a number of important appointments, some of which were as follows:

Philip Darling, chairman, E. F. Miller, W. E. Jerauld, George H. Clark, I. E. Moultrop, A. M. Houser, A. L. Fitch and G. S. Coffin were approved as a Special Committee on Sudden Initial Pop Lift of Safety Valves.

M. D. Church was approved on the Power Test Codes Committee on Steam Turbines and Samuel B. Flagg on the Committee on Instruments and Apparatus.

A. G. Christie, C. E. Lucke, P. Diserens, E. F. Miller and G. A. Orrok were approved as members of the Main Committee on Power Test Codes.

John W. Upp, chairman, John Price Jackson, Carl M. Hansen, H. L. Whittemore, and W. A. Viall were approved as a Standing Committee on all Safety Codes except the Boiler Code.

The committee appointments approved by the Executive Committee were: H. V. Wille, Sub-committee on Air Tanks and Pressure Vessels of the Boiler Code; S. H. Barnum, F. G. Cox and L. E. Connelly, representatives of the American Boiler Manufacturers Association, on the Boiler Code Subcommittee on Rules for Inspection. Louis Doelling Walter Jones, C. R. Neeson, R. F. Massa, A. W. Mellowes and J. E. Starr, as representatives of the society on the Sectional Committee on Safety Code for Mechanical Refrigeration; L. V. Benet to represent the society at the exposition of the Association des Ingenieurs Sortis de L'Ecole de Liege; A. A. Potter to represent the society at the Steel Treater's Convention.

Recommendations of the Tenth Annual Safety Congress

According to resolutions adopted at the Tenth Annual Congress of the National Safety Council, held recently at the Massachusetts State House in Boston, 75 per cent of the 80,000 accidental deaths and millions of injuries occurring every year in the United States are preventable; it is said that experimental campaigns in seven cities have brought down public accidents by from 25 to 40 per cent, and that further efforts will make possible additional reductions. It is declared also that the direct economic cost of accidents in industry is more than one billion dollars annually.

As a program for reducing this loss in life and wealth, five recommendations were made, as follows: Dangerous machinery should be equipped with safety guards and appliances; when necessary, factory equipment should be redesigned and rebuilt, and dangerous processes should be improved, in order to decrease the accident hazard; workmen and foremen should be educated in safety methods; the safety idea should be taught students in schools, colleges and universities; intensive and permanent campaigns against accidents should be inaugurated by means of city and state safety councils.

At the first meeting, after the Congress, of the executive committee of the council, the following vice presidents were elected to the council: David S. Beyer, B. F. Tillson, F. A. Davidson, C. D. Scott and David Van Schaack. Other new officers of the Council are W. E. Worth, secretary-treasurer; W. H. Cameron, executive secretary; Sidney J. Williams, (re-elected) chief engineer The new president is Arthur H. Young, manager of industrial relations for the International Harvester Co., of Chicago.

Engineering and Industry Building Proposed in San Francisco

Plans are under way for interesting a large number of San Francisco engineers in an enterprise for constructing and operating a 20- to 25-story office building that would be recognized as a center of engineering activity The movement is being fostered by the San Francisco Electrical Development League, which estimates the cost of the project at about $2,000,000. The League appropriated $150 for circularizing the 6,000 engineering and industrial firms of the bay regions with a questionnaire to ascertain popular sentiment in the matter, and has appointed a board of 19 regents to direct affairs connected with the project. The board consists of the presidents or chairmen of practically all the important engineering or industrial organizations of San Francisco and three representatives at large, the latter being John A. Britton, W. E. Creed and Mortimer Fleishbacker.

A. S. M. E. Will Stress Elimination of Waste at Annual Meeting

At the coming annual meeting of the American Society of Mechanical Engineers, which is scheduled for Dec. 5-9, in New York City, the most important topic to be considered will be American Engineering Council's report on the Elimination of Waste in Industry. This is in accordance with the recommendation made when the report was issued that each technical society should give intensive treatment to the subject. Of course other matters will be taken up at the meeting, but it is understood that an effort will be made to tie them in as closely as possible with the engineering phases of the waste problem.

A new feature will be a session conducted entirely by student members. The Committee on Relations with Colleges is making preparations for the session and plans to have the preparation, presentation and discussion of papers at this session done entirely by students.

It is announced that the program will be more elaborate than that of last year's meeting and that the affair will last for five days. To make better use of the available time, an effort will be made to begin all morning sessions promptly at 9:30. Other details and features will follow more or less closely the custom of previous meetings.

Million Horsepower Application Filed by Southern California Edison Company

Among the applications for a preliminary permit received by the Federal Power Commission during the week ended Oct. 15 is an especially important one involving water-power development on the Colorado River in Mohave County, Ariz., and Clark County, Nev., which is asked for by the Southern California Edison Co., of Los Angeles.

Present plans are for a dam and power house at two different points on the river, one in Boulder Canyon and one in Pyramid Canyon. The estimated power capacity of the Colorado River is put at 900,000 hp. The total installed capacity covered in the application is 1,200,000 hp. It is understood that this application is in conflict with two others, one being that of Edward A. Bayard of Seligman, Ariz., and one of the city of Los Angeles.

Over 16,000,000 Hp. of Water Power Applications Filed

A recent review of the activities of the Federal Power Commission indicates the enormous extent of water-power development under contemplation. Up to Oct. 8 there had been filed with the Commission 256 applications involving a total of over 16,000,000 hp., of which about 10,500,000 hp. is primary power and 5,500,000 secondary. Of course most of these applications are for public utilities.

In 1917 the total water-power development in the United States was about 7,000,000 hp., while today, according to the commission's estimates, the total development is probably between 8,000,000 and 9,000,000 hp. Therefore the development planned, 16,000,000 hp., is about twice the present existing capacity of water-power plants.

The amount of money involved is likewise tremendous. In 1917 the average investment in plant and equipment for public-utility water-power stations of over 1,000 hp. capacity was $240 per hp. If the projects before the commission required only half that amount, the total would amount to $2,000,000,000, in addition to which there would be involved even more than that for distribution systems, customer's installations, etc.

While it is true that the country could not at once absorb the 16,000,000 hp. that has been applied for, and many applications will never be carried to completion, it is believed that the greater part of this development will be realized. It is felt that with the return of normal business conditions and industrial expansion there will come unprecedented activity in the use of water power.

New Publications

Testing of Thermometers. Circular No. 8, published by the United States Bureau of Standards, Department of Commerce, Washington, D. C. Price 5c.

Gives such information as will be useful to those wishing to send thermometers to the Bureau for test.

The Thermal Conductivity and Diffusivity of Concrete. By A. P. Carman and R. A. Nelson. Published by the Engineering Experiment Station of the University of Illinois, Urbana, Ill. Paper, 6 x 9 in.; 40 pages. Price, 20 cents.

Although the methods used in testing samples of various mixtures of concrete to determine their heat-conducting qualities are not likely to interest power-plant men, it is possible that the results of these tests, as given in a number of tables in this bulletin, may be of some use to them.

Mechanical World Year Book. Published by Emmott & Co., Ltd., Manchester, England, 1921. Cloth; 4 x 6 in.; 328 pages; 83 illustrations. Price, 2s. 6d.

This book represents the thirty-fourth edition of this work and now contains 328 pages of text and 319 pages of advertisements of concerns doing business in power-plant and machine-shop equipment in England. The text deals chiefly with power-plant and machine-shop work, and although representing British practice, a large percentage of the material is of service to power engineers in general. The book also contains a French, Russian and Spanish buyers' guide which will be of service to engineers visiting these countries.

Three-Phase Induction Motors. By L. E. Wood. Published by the *Electrical Review*, London, England, 1921. Cloth; 5 x 7 in; 130 pages; 72 illustrations. Price, 6s. 6d.

This book is a practical treatise on the three-phase induction motor, intended for those who are responsible for the operation and maintenance of this class of equipment. Being primarily for the practical man, mathematical treatment has been avoided. Both the squirrel-cage and slip-ring types of motors are treated of. An attempt has been made to give a general idea of the construction of the machines, how they operate, winding of coils and placing them in the slots, starting apparatus and the location of faults. Of course in the limited space devoted to these subjects they cannot be treated to the extent that many might like to see them. However, the practical electrical man will find many useful hints in this little book.

Central-Station Rates in Theory and Practice. By H. E. Eisenmenger. Published by Frederick J. Drake & Co., Chicago, Ill., 1921. Flexible binding; 4½ x 6¾ in.; 382 pages; illustrated. Price, $2.50.

The text of this book was first published in twenty-five consecutive articles, during the latter half of 1920, in the *Electrical Review*. It has been the intention of the author to produce a book that would be of use to every student of electric rates, consequently some parts of the text will be found too elementary for advanced students, while other parts will be of service only to those who have considerable knowledge of the subject. The book is divided into six sections: Cost of electric service; price of electric service; systems of charging; rate analysis; accuracy of rates; and public utilities and public regulation, the last being in the form of a number of appendices, explaining the various factors that enter into rate making and how they influence the charge. Mathematics has been used where necessary, but these portions have been segregated from the rest of the text, so that they may be avoided by those not interested in this part of rate making.

Diagnosis of Troubles in Eelectrical Machines. By Miles Walker. Published by Longmans, Green and Co., New York City and London, 1921. Cloth; 6 x 10 in.; 450 pages; 332 illustrations. Price, $10.50.

Most books on troubles in electrical machinery confine the treatment to those that are encountered by the practical electrician. In this book not only the elementary problems have been treated of, but also those in which the investigator may have to check every element in the construction of the machine, to determine the validity of the design. The book is divided into 16 chapters: Breakdown of insulation; over-heating; low efficiency; miscellaneous troubles; use of victor diagrams; alternating-current generators; two chapters on direct-current generators; two chapters on sparking at brushes; direct-current motors; four chapters on rotary converters and motor generators; induction motors; and the use of the oscillograph in commercial testing. Not only are the symptoms and the remedy of the trouble given, but in many cases a mathematical analysis of the effects is gone into. The book is one intended primarily for electrical engineers and should find a wide field of usefulness with this class of reader. However, much of the material can be grasped by the practical electrician who is closely associated with electrical machinery.

Obituary

John F. Robertson, of the John F. Robertson Co., Pittsburgh, Pa., died recently at the Suburban General Hospital in Bellevue, Pa., after an illness of nine days. He was born in Scotland in 1873, and for the last 33 years had been a resident of Pittsburgh. He was president of the Lawrenceville Bronze Co., vice president of the Superior Brick Co. and president of the Neville Lubricating Co. He was also a member of the Pittsburgh Chamber of Commerce and the National Association of Stationary Engineers. The John F. Robertson Co. is to continue business under the same name.

Personals

Alan A. Wood, for years associated in an engineering and sales capacity with the Providence plant of the Builders Iron Foundry and the Diamond Machine Co., is now sales manager in the Philadelphia district, having offices at 419 Widener Building, Philadelphia.

A. L. McClurg, who represented the Harrison Safety Boiler Works in Boston away back in the 90's, has established the McClurg Engineering Co. in St. Paul, where he is again handling the Cochrane line, Fisher governors, traps, humidifiers, ventilators, sterilizers, etc.

Society Affairs

Calendar

Taylor Society—Annual meeting at New York City, Dec. 1-3. Managing director, H. S. Person, 29 West 39th St., New York City.

American Society of Mechanical Engineers—Annual meeting at New York City, Dec. 5-8. Topic, "Elimination of Waste." Secy., Calvin W. Rice, 29 West Thirty-ninth St., New York City.

National Association of Practical Refrigerating Engineers—Annual convention at Hotel Lorraine, Philadelphia, Nov. 30-Dec. 3. Secy., Edward H. Fox, 5707 West Lake St., Chicago.

American Society of Refrigerating Engineers—Annual meeting at New York City, Dec. 5-7. Secy., William H. Ross, 154 Nassau Street, New York City.

American Gas Association—Third annual convention and manufacturers' exhibition at Congress and Auditorium Hotels, Chicago, Nov. 7-12. Charles W. Person, 130 East Fifteenth St., New York City.

Philadelphia Section, Society of Automotive Engineers, will meet Nov. 22 at 8:15 p.m. to consider "Fuel and Diesel Engines."

The New England Water Works Association is to meet Nov. 9 at the American House, 56 Hanover St., Boston, Mass., at 2 p.m. F. W. Dean will give an illustrated paper on "Steam Boilers."

The Providence Engineering Society will hold a joint meeting with the Rhode Island Section of the A. S. M. E. on Nov. 15. Alfred D. Flinn, secretary of the United Engineering Society, will speak on "Engineering Co-operation, Past, Present and Future."

New Haven Branch, A. S. M. E., is to hold an afternoon and evening meeting on Nov. 14, which will be a symposium on the economics of the coal problem in Connecticut, and will be held jointly with the New Haven Chamber of Commerce and local sections of engineering societies. Two papers will be given; "Quality and Cost Factors in the Mining of Coal," by J. W. Paul, of the Bureau of Mines; and "Transportation of Coal," by H. W. Payne, consulting engineer.

Business Items

The Detroit Seamless Steel Tubes Co., Detroit, Mich., has appointed C. H. Hobbs assistant general manager of sales.

The Joseph L. Skeldon Engineering Co., Toledo, Ohio, has bought the McNaul Boiler Manufacturing Co., of Toledo, and will continue the manufacture of the McNaul boiler.

The Chain Belt Co., Milwaukee, Wis., has taken offices at 735 Ellicott Square, Buffalo, N. Y., and has appointed T. E. Cocker as district manager of that territory for the Rex line of chains, sprocket wheels, etc.

The Westinghouse Electric International Co. has appointed D. K. Chadbourne manager of its New York office. Mr. Chadbourne spent six years with the Allis-Chalmers Co., joining the George Cutter Co. in 1912, and remaining with the latter people until their affiliation with the Westinghouse company.

The Quigley Furnace Specialties Co., Inc., 26 Cortlandt St., New York City, has announced that its pulverized-fuel department has been taken over by the Hardinge Co., 120 Broadway, New York City, which will keep the organization intact and carry on the work as did the Quigley company. The latter company will continue its refractory specialties business as before.

The Allen-Sherman-Hoff Co. has called attention to a Business Item in the Oct. 25 issue, announcing the organization of the company, in which it was stated that the president, M. C. Sherman, was previously with the Sherman Engineering Co. It seems that this is the truth, but not the whole truth; inasmuch as Mr. Sherman remains at the head of the Sherman Engineering Co. and that company continues to operate as before.

The Richardson-Phenix Co. and the **S. F. Bowser Co.** have announced their consolidation. The former is well known for its development of lubricating devices and appliances for filtration and reclamation of lubricating oils, while the latter is equally prominent as a manufacturer of pumps and storage systems for gasoline and oils. The name and personnel of each company remains unchanged. Executive headquarters will be established in the new office building of the Bowser company in Fort Wayne, Ind. S. F. Bowser is president of the Bowser company. S. B. Bechtel, vice president of that company, becomes vice president and general manager of Richardson-Phenix, while J. William Peterson, president of the latter company, becomes vice president of the Bowser company. L. E. Strothman, vice president and general manager of the Richardson-Phenix Company, and vice president elect of the A. S. M. E., has been in ill health for some time and is to have an extended leave of absence.

Trade Catalogs

Mine Hoists—Nordberg Manufacturing Co., Milwaukee, Wis. Bulletin containing interesting photographs of big mine plants where Nordberg hoists are used.

Industrial Heating Furnaces—W. S. Rockwell Co., 50 Church St., New York City. Bulletin No. 239, 8 pages, describing a new type of furnace for industrial heating requirements.

Corliss Engines—C. & G. Cooper Co., Mount Vernon, Ohio. Bulletin 54, illustrating clearly the different parts of Cooper Corliss engines, which are built in sizes from 150 to 5,000 hp.

Blowoff Valves.—The Elliott Co., Pittsburgh, Pa., Bulletin K, on a new self-cleaning blowoff valve that uses a jet of steam or clean water for cleaning the disc and seat just before closing.

Cranes—Whiting Corp., Harvey, Ill. Crane Catalog No. 158, 6 x 9 in. 80 pages, on lifting machinery, from traveling cranes for moving locomotives to hand-operated jib cranes for light work.

Piston Rings—Ever-Tyte Piston Ring Division, 1600 Kingsland Ave., Wellston District, St. Louis, Mo. "Some Evidence," relating to a three-piece, interlocking piston ring for steam and internal-combustion engines.

Pipe-Threading Machines—Williams Tool Corp., Erie, Pa. "Don't Let It Happen to You," an entertaining little 60-page booklet that also contains practical information on the installation and operation of pipe-threading machines.

Hoists—Gillis & Geohegan, 532 West Broadway, New York City. An 8½ x 11 in. 20-page catalog, describing a hand or electrically operated telescopic hoist for lifting ash cans, barrels, etc., from the cellar to the sidewalk and for miscellaneous uses in the plant.

Pneumatic Apparatus — Chicago Pneumatic Tool Co., 6 East 44th St., New York City. Bulletin 710, 6 x 9 in., 28 pages, on dry vacuum pumps, built in steam, belt and motor-driven models up to about 200 hp. A circular is also available, No. 674, giving specifications of portable pneumatic tools.

FUEL PRICES

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run bases, f.o.b. mines):

Coal	Market Quoting	Oct. 24, 1921	Nov. 2, 1921
Pool 1,	New York	$3.40	$3.00@3.50
Pocahontas,	Columbus	2.65	2.35@2.75
Clearfield,	Boston	1.95	1.75@2.15
Somerset,	Boston	1.90	1.60@2.15
Pittsburgh,	Pittsburgh	2.15	2.10@2.20
Kanawha,	Columbus	2.15	2.00@2.25
Hocking,	Columbus	2.10	2.00@2.15
Pittsburgh No. 8	Cleveland	2.20	2.10@2.15
Franklin, Ill.,	Chicago	3.00	2.00@3.50
Central, Ill.,	Chicago	2.25	2.00@2.50
Ind. 4th Vein,	Chicago	2.55	2.00@2.75
Standard,	St. Louis	2.00	1.90@2.00
West Ky.,	Louisville	2.40	1.85@3.00
Big Seam,	Birmingham	2.15	2.00@2.30
S. E. Ky.,	Louisville	2.20	2.00@2.40

New York — On Nov. 2, Port Arthur light oil 22@25 deg. Baumé, 5¼c. per gal.; 30@35 deg., 7c. per gal., f.o.b. Bayonne, N. J.

Chicago—Oct. 29, for 24@28 deg. Baumé, $1@$1.10 per bbl.; 32@36 deg. 3@3¼c. per gal. in tank cars f.o.b. Oklahoma refinery, or freight adjusted.

Pittsburgh — On Oct. 31 f.o.b. refinery; Pennsylvania, 36@40 deg., 6¼@6¾c. Oklahoma, 24@30 deg., $1.05 per bbl.; gas oil, 32@34 deg., 3¼@3½c. per gal., 36@38 deg., 3¾c., 38@40 deg., 4@4½c. per gal.

St. Louis — Oct. 22, prices f.o.b. cars, tank lots; 24@26 deg. Baumé, $1 per bbl.; 26@28 deg., $1.10; 28@30 deg., $1.20; 32@34 deg., 5c. per gal.

Philadelphia — On Oct. 31, 26@28 deg. Baumé, Oklahoma, 50c. per bbl.; 30@34 deg., Oklahoma (group 3), 75c. per bbl.; 16@20 deg. Seabord, 3½c. per gal.

Cincinnati — Oct. 31, for 26@30 deg. Baumé, 5¼c.; Diesel, 30@32 deg., 5¾c. per gal.; 32@34 deg., 6c. per gal.

Cleveland — Oct. 31, for 26@30 deg. Baumé, 4½c. per gal.

New Construction

PROPOSED WORK

Conn., Hartford — The Knights of Pythias, Bldg. Assn., J. K. Baskerville, Pres., plans to build a 4 story Stores and Club building on High St. About $400,000. Architect not selected.

N. Y., Buffalo—S. G. Hurst, Brisbane Bldg., plans to build a 6 story, 110 x 183 ft. stores and office building on Huron St. Cost to exceed $300,000.

N. Y., Flushing—The Bd. Educ., 500 Park Ave., New York City, will soon receive bids for school No. 72, on Maspeth near Grand Aves. About $450,000. C. B. J. Snyder, 28th floor, Municipal Bldg., New York City, Archt. and Engr.

N. Y., New York—G. Nordham, Archt., 18 West 34th St., will soon receive bids for a 6 story apartment on Tremont Ave. About $750,000. Owner's name withheld.

N. Y., New York—The North River Savings Bank, 31 West 34th St., plans to build a 70 x 100 ft. bank at 206-212 West 34th St. About $350,000. Architect not selected.

N. Y., New York—The Oneida Bleachery, Inc., 320 Bway., is in the market for an Ingersoll Rand, size 8 x 8, belt driven, air compressor to carry 60 lb. pressure.

Pa., Philadelphia—J. W. Hollawell, Broad and Chestnut Sts., is having plans prepared for a 10 story, 50 x 160 ft. office building at 1612-28 Sansom St. About $300,000. Private plans.

Va., Richmond—H. Morrison Co., 1010 4th Ave., is in the market for 3 boilers, one 80 h.p., one 60 h.p. H. R. T. and one 60 h.p. Vertical, one 4 in. centrifugal sand pump.

W. Va., Point Pleasant—The Auto-Motor Corp., Charleston, W. Va., plans to build a 4 story factory, consisting of 3 units. About $250,000. Architect not selected.

N. C., High Point—The Commercial Natl. Bank will receive bids about Jan. 1 for a 10 story, 50 x 115 ft. bank and office building on Main St. About $1,000,000. C. G. Hartman, Greensboro, Archt. Noted Oct. 4.

N. C., Wilson — The Bd. of Trustees, School Dist., will receive bids until Nov. 23 for a high school. About $300,000. Separate contract for a heating and ventilating system, etc. C. L. Coon, Supt. C. C. Watson, Archt.

Fla., Green Cove Springs—The town voted a bond issue of $150,000 for paving, sewers and repairing water and light plants.

La., New Orleans—W. Ball, Purch. Agt., City Hall will soon receive bids for a 21-ton refrigerator plant to be installed in the Poydras St. market.

La., New Orleans — The Sewerage & Water Bd., Room 401, 526 Carondelet St., will receive bids until Dec. 23 for two 55,000 gal. field oil tanks and three 1,500-1,800 hp. water tube boilers.

Ky., Louisville—R. D. Weakley, Archt., 233 4th St., is receiving bids for a 5 story, 75 x 200 ft. temple at 200 Market St. for the Union Labor Organization, 306 West Jefferson St. About $350,000.

O., Canton—The Continental Clay Co., Zinninger Bldg., is having plans prepared for a 1 story, 100 x 300 ft. sewer pipe factory. About $500,000. Engineers not announced.

O., Cleveland—The Chester Gardens Co., c/o S. H. White, Archt., 1032 Schofield Bldg., is receiving bids for a 9 story, 80 x 350 ft. apartment on East 116th St. and Shaker Blvd. About $1,500,000.

O., Cleveland—The city is having plans prepared for a filtration plant, pumping station and reservoir. About $10,000,000. A. V. Ruggles, City Hall, Engr.

O., Cleveland — The Shubert Vaudeville Theatres, c/o R. McLaughlin, Ohio Theatre, East 17th St. and Euclid Ave., is having plans prepared for a 16 story office and theatre building on Huron Rd. About $2,500,000. T. Lamb, 644 8th Ave., New York City, Archt.

O., Columbus — The Bd. Educ. E. L. McCune, Clk., Town and High Sts., has had plans prepared for a 3 story, 275 x 290 ft. school on Arcadia Ave. About $985,000. F. L. Packard, New Hayden Bldg., Archt.

O., Columbus—The Bd. of Trustees, C. L. Steel, Secy., will receive bids until Nov 18 for an 18 x 204 ft. power house. About $300,000. Equipment, including a 500-kw. turbine, aerial traveling crane, switchboard, etc., will be provided for later. J. N. Bradford, Archt.

O., Findlay — The Glenwood Motor Car Co., c/o B. J. Cline, East 71st and Euclid Aves., is receiving bids for a 1 story, 100 x 700 ft. auto factory. About $250,000. Private plans.

O., Martins Ferry—The city is having plans prepared for improvements to municipal light and power plant. J. N. Chester, Union Bank Bldg., Pittsburg, Engrs.

O., Toledo—The Bd. Educ. received lowest bid for heating and ventilating system for the proposed South high school from A. Bentley & Sons Co., 201-31 Belmont Ave., $64,990. Noted Oct. 11.

O., Youngstown—The city is having plans prepared for a 1 story, 150 x 205 ft. auditorium on Wick and Park Sts. About $500,000. Helmle & Corbett, 132 West 42nd., New York City, Archts.

Ill., Chicago—I. O. Ackley, 1447 East 63rd St., plans to build a 10 story, 125 x 125 ft. apartment, including a steam heating system on Hyde Park Blvd. About $1,000,000. Architect not selected.

Ill., Chicago—T. P. Bona, c/o A. Foster, Archt., 56th and Randolph Sts., is receiving bids for a 3 and 1 story school and heating plant on 33rd and Morgan Sts. About $175,000.

Ill., Chicago—A. Gumbiner, 10 South La Salle St., plans to build a 100 x 140 ft. theater, including a steam heating system on Sheridan Rd. and Lawrence Ave. About $1,000,000. Architect not selected.

Ill., Chicago—W. G. Souders, 218 South La Salle St., is having plans prepared for an 8 story, 125 x 150 ft. apartment, including a steam heating system on Lake View Ave. and Deming Pl. About $700,000. R. S. De Golyer, 7 South Dearborn St., Archt.

Ill., Chicago—The Washington Park Natl. Bank, 63rd and Evans Aves., is having plans prepared for an 8 story, 100 x 125 ft. bank and office building, including a steam heating system. About $500,000. A. Schwartz, 118 North LaSalle St., Archt.

Ill., Danville—The Bd. Educ., c/o W. Smith, Pres., is having plans prepared for a 3 story high school, including a steam heating system. About $500,000. C. M. Lewis & Dougherty, Temple Bldg., Archts.

Ill., Danville — Van Volkenburg Bros., Savory Hotel, are having plans prepared for a 7 story hotel, including a steam heating system. About $400,000. Lewis & Dougherty, Temple Bldg., Archts.

Wis., Brillion—The city, E. Guiett, Clk., will receive bids until Nov. 14 for a pumping station, well and waterworks system, including equipment. About $30,000. J. Donahue, 8th St., Sheboygan, Engr.

Wis., Dodgeville—The Wisconsin River Power Co., Gay Bldg., Madison, plans to build a 2 story, 60 x 85 ft. electric sub and power station. About $55,000. Architect not selected.

Wis., Madison—M. Heiman, c/o Stanley Hanks Co., Bank of Wisconsin Bldg., has purchased a site and plans to build a 1 and 2 story, 35 x 125 ft. theater bldg., including a steam heating system at 216 State St. About $250,000. Architect not selected.

Ill., Waukegan—Lake County, c/o C. Holstein, 225 Washington St., is having plans prepared for a 3 story, 200 x 200 ft. court house, including a steam heating system. About $400,000. Beers, Schling & Bailey, 53 West Jackson Blvd., Chicago, Archts. Noted June 14.

Wis., Wauwatosa — The Milwaukee County Bd. of Trustees, W. L. Coffey, Bus. Mgr., is having surveys made for a power and heating plant. Cost between $300,000 and $500,000. Vaughn & Meyer, Security Bldg., Milwaukee, Engrs.

Minn., Cloquet—The city will soon award the contract for a pumping station, power line and the installation of pump and motor, water main, etc. About $35,000. J. Wilson, 1st Natl. Bank Bldg., Duluth, Engr. Noted Sept. 13.

Minn., St. Paul—The Dept. of Education, L. S. Ferguson, Comr., City Hall, is having plans prepared for a 3 story, 70 x 260 ft. school, including a steam heating system on Garfield and Western Aves. About $350,000. C. A. Hausler, City Archt.

Kan., Anthony — The city, c/o S. E. Thompson, Clk., will receive bids until Nov. 10 for one 300 kw. steam engine, one 150 hp. water tube boiler, jet condenser and chimney, 100 ft. high x 60 in. Black and Veatch, Mutual Bldg., Kansas City, Mo., Engr.

Kan., Wichita—The Wichita Ice & Storage Co., c/o C. W. Southward, Pres., 213 South Rock Island Ave., is having plans prepared for a 5 story, 75 x 90 ft. ice plant. About $200,000. G. E. Wells, Boatmen Bank Bldg., St. Louis, Mo., Archt.

Neb., Lincoln—The city will soon award the contract for two 500 h.p. water tube boilers for the water and electric light plant here. G. M. Bates, Lincoln, City Engr.

Neb., Omaha—The Elks Lodge No. 39, c/o O. Neilson, Secy., plans to build an 8 or 10 story Elks' home, including a steam heating system. About $1,000,000. Architect not selected.

Neb., Randolph—The city, c/o C. Blizzard, Clk., plans an addition to electric light plant. About $65,000.

Mo., Ash Grove—The Ash Grove Ice Plant Co. is having plans prepared for a 1 story ice plant on Main St. About $15,000 Private plans.

Mo., Koch—The Bd. Public Service, c/o E. R. Kinsey, Pres., City Hall, St. Louis, is having plans prepared for a 3 story, 65 x 136 ft. hospital here, including a steam heating system. About $340,000. L. Preuss, care of owner, Archt.

Mo., Monett—R. E. Brunner, Commerce Bldg., Kansas City, has had plans prepared and will soon receive bids for a hydro-electric plant. About $30,000. R. Waddell, City Hall, Engr.

Mo., Springfield—Ben Adhem Shrine, c/o G. Glendorf, Landers Bldg., will soon receive bids for a 3 story, 140 x 267 ft. masonic temple. About $300,000. Heckenlively & Mark, Landers Bldg., Archts. Former bids rejected. Noted Jan. 11.

Mo., Springfield — The State Teachers College, c/o C. M. Hill, Pres., is having plans prepared for a 2 story, 90 x 230 ft. college, including a steam heating system. About $250,000. Hawkins & Holner, McDaniel Bldg., Archts.

Mo., St. Louis—The Aubert Photo Play Co., Title Guaranty Bldg., will soon award the contract for a theatre including a steam heating system on Aubert and Easton Sts. About $250,000. P. Klingenschmidt, 5086 Wells Ave., Archt.

Ark., Gravette—H. D. Jenkins, Eureka Springs, plans to build a power and ice plant. About $25,000. R. A. Nilson, Harrison, Engr.

Okla., Hugo — Jacobson Eng. Co., 533 Metropolitan Bank Bldg., Minneapolis, Minn., Engrs., are making surveys for a hydro-electric power plant to include a dam with 300 ft. head to develop 70,000 h.p., complete machinery, etc.

Okla., Purcell—The city plans waterworks and electrical improvements. Benham & Mullergran, Firestone Bldg., Kansas City, Mo., Engrs.

Cal., Long Beach—R. H. Young & Associates, 510 Long Beach Trust & Savings Bank Bldg., plans to build an 8 or 12 story, 134 x 135 ft. apartment on Ocean Ave. and Cedar Way. About $700,000. Architect not selected.

Cal., San Diego—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., received bids for boiler plant equipment at the Naval Base Hospital from W. E. Keer, Constr. Co. & W. Simpson Constr. Co., Morris Strong Bldg., Los Angeles, $49,095; General Elec. Engr. Co., 449 West 42nd St., New York City, $52,876; and the Carroll Elec. Co., 714 12th St., N. W., Wash., D. C., $50,750. Spec. 4494. Noted Oct. 16.

Cal., San Francisco — The Bd. Public Wks., will receive bids until Nov. 16 for a 3 story addition to the Mission high school on 18th St. About $460,000. Separate contracts on heating and ventilating, etc. J. Reid, Jr., city Archt.

Ont., Gravenhurst—The Natl. Sanitorium Assn., E. L. Ruddy, Chn., 372 Spadina Ave., Toronto, will soon award the contract for a 3 story hospital including a steam and mechanical ventilation system. About $600,000. C. S. Cobb, 71 Bay St., Toronto, Archt.

Ont., Petrolea—The Peninsular Sugar Co. plans to build a refinery here, 600 tons capacity. About $2,000,000. F. H. Hubbard, Mgr. of Ottawa Sugar Co., Ottawa, O., Pres.

B. C., Prince Rupert—The Prince Rupert Pulp and Paper Co., 602 Pacific Bldg., Vancouver, plans to build a pulp mill here, 1st unit, 40 tons per day capacity cost about $1,000,000, ultimate capacity 200 tons per day. Total cost $5,000,000. Engineer not selected.

CONTRACTS AWARDED

Conn., Middletown — The Connecticut Hospital for Insane, South Farms, has awarded the contract for a 2 story, 100 x 235 ft. ward building at hospital to H. Wales Lines Co., 134 State St., Meriden Ct. About $325,000. A steam heating system will be installed. Noted Oct. 18.

N. Y., New York—The Almab Corp., A. A. Volk, Pres., 550 West 20th St., has awarded the contract for a 9 story apartment on East 88th St. near 5th Ave. to T. J. Steen, 477 5th Ave. About $750,000.

N. Y., New York—Ludwig Bauman & Co., 8th Ave. and 35th St., has awarded the contract for a 12 story store, warehouse and office bldg. on 8th Ave. between 35th and 36th Sts. to G. Richard Davis Co., 30 East 42nd St.

N. Y., New York—W. L. Phelan, 1875 Harrison Ave., will build a 5 story, 90 x 175 ft. apartment on Harrison Ave. About $250,000. Work will be done by separate contracts.

N. Y., New York—I. Polstein, 280 Madison Ave., will build an 11 story, 95 x 125 ft. apartment at 1125 Madison Ave. About $750,000. Owner will build by day labor.

N. Y., New York—S. Shapiro, c/o C. Kreymborg, Archt., 2534 Marion Ave., will build four 5 story apartments in Bronx Park, South. About $200,000 each. Work will be done by separate contracts.

Pa., Braddock — The Diamond Ice Co. has awarded the contract for a 1 and 2 story, 30 x 44, 10 x 40 and 15 x 29 ft. addition to ice plant on 6th St. to T. George, 1133 Bell Ave. About $50,000.

Pa., Philadelphia — J. W. Hollawell, Broad and Chestnut Sts., has awarded the contract for a 10 story, 42 x 78 ft. office building at 1513-21 Sansom St., to Doyle & Co., 1519 Sansom St., $250,000. Steam heating system will be installed.

Pa., Philadelphia — The Medical Arts Realty Co., 16th and Walnut Sts., will build a 15 story, 40 x 117 ft. office building on 16th and Walnut Sts. About $300,000. Work will be done by day labor. Bids will be received later for heating and ventilating system.

N. C., Goldsboro—The State Hospital for Insane has awarded the contract for a power house, etc., to the C. V. York Constr. Co., Raleigh, $60,000. Noted Oct. 11.

O., Ashtabula—The city has awarded the contract for an 80 x 80 ft. power plant to the Service Constr. Co., 6110 Euclid Ave., Cleveland, $63,480. Noted Oct. 4.

O., Cleveland—The city has awarded the contract for a steam boiler plant for the new public hall on East 6th St. and St. Clair Ave. to Chappell Warren Co., 1837 St. Clair Ave., $81,700. Noted Oct. 28.

O., Middletown—The Middletown Hotel Co. has awarded the contract for a 5 story, 130 x 168 ft. hotel to Dwight P. Robinson Co., Inc., 125 East 46th St., New York City. About $400,000. Noted Sept. 27.

Ill., Rockford — The city, c/o W. C. Wilson, has awarded the contract for equipment, piping and covering for pumping station to C. A. Hooper Co., 642 State St., Madison, Wis., $12,000.

Wis., Milwaukee—The city has awarded the contract for furnishing and erecting 3 pumps for the Riverside pumping station to Allis Chalmers Mfg. Co., West Allis, $641,500. Noted Oct. 11.

Ia., Des Moines—The Des Moines Gas Co., 7th and High Sts., has awarded the contract for a 1 story, 50 x 55 ft. addition to power plant at 107 East Vine St. to C. F. Weitz & Sons, 713 Mulberry St. About $50,000.

Kan., Coffeyville—E. R. Lawson, Nowata, Okla., has awarded the contract for a 1 and 2 story ice plant to University Constr. Co. About $100,000. Noted Oct. 4.

Okla., Duncan—The city has awarded the contract for 800-kw. municipal light plant, distributing system and white way to Merkle Mchy. Co., 1733 Walnut St., Kansas City, Mo., $227,824.

Cal., San Diego—The San Diego Ice & Cold Storage Co., 110 9th St., will build a 5 story, 105 x 158 ft. cold storage plant including 2 ice tanks, 60 tons capacity each and engine room. About $300,000. Work will be done by day labor under supervision of F. P. Allen, 1st Natl. Bank Bldg., Archt.

Que., Montreal — The city has awarded the contract for three 30,000,000 gal. pumps to the Dominion Eng. Wks., Ltd. About $76,500. Noted Oct. 4.

Que., Montreal—The Notre Dame Hospital, Notre Dame St., E., has awarded the contract for a 5 story, 75 x 100 ft. hospital on Panet St. to A. Gratton, 5th Ave., Montreal, $500,000.

Ont., Walkerville—The School Bd., A. E. Cock, Secy., has awarded the contract for a heating and ventilating system in the proposed 2 story high school on Huron St. to the Drake Avery Co., 103 John St., N., Hamilton. Noted July 12.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

Hose, belting, packing and boiler specialties have remained firm as to price in the last three months, with most of the other power-plant supplies declining. Greater discounts can be obtained on asbestos covering for pipe and boilers and on wrought-iron pipe than a month ago. Linseed oil averages 7¾c. lower over the country. Cement has dropped 10c. per bbl. in New York. Steel shapes and plates are quoted at $1.50@$1.65 per 100 lb., Pittsburgh mill, depending upon size of order, with mill shipments, New York, $1.88@$2.03. Boiler tubes and refractory materials are cheaper than a month ago.

POWER-PLANT SUPPLIES

HOSE—

	Fire	50-Ft. Lengths
Underwriters' 2½-in.		56c. per ft.
Common, 2½-in.		50–5%

	Air	
	First Grade	Second Grade
¾-in. per ft.	$0.38	$0.22½

Steam—Discounts from List

First grade	Second grade	Third grade
40–10%	50–5%	50–10–5%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition	Best grade
60–5%	50–10%

LEATHER BELTING—Present discounts from list in fair quantities (½ doz rolls):

Light Grade	Medium Grade	Heavy Grade
50–5%	45%	40%

RAWHIDE LACING { For cut, best grade, 50–10%, 2nd grade, 60%. For laces in sides, best, 41c. per sq.ft.; 2nd, 39c. Semi-tanned: cut, 50%; sides, 43c. per sq.ft.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam	$1.00
Asbestos for high-pressure steam	2.00
Duck and rubber for piston packing	1.00
Flax, regular	1.20
Flax, waterproofed	1.70
Compressed asbestos sheet	1.00
Wire insertion asbestos sheet	1.50
Rubber sheet	.45
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.25
Asbestos wick, ½- and 1-lb. balls	.75

PIPE AND BOILER COVERING—Discounts are as follows:

85% magnesia high presure		40% off
For low-pressure heating and return lines	4-ply	60% off
	3-ply	62% off
	2-ply	64% off

PORTLAND CEMENT—New York, $2.40 without bags, in cargo lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $2.88 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York Current	Cleveland	Chicago
White	7.50@10.00	12.00	12.00
Colored mixed	5.50@ 9.00	9.00	10.00

WIPING CLOTHS—Jobbers' price per 1,000 is as follows:

	13½ x 13¼	13½ x 20½
Cleveland	$55.00	$65.00
Chica[illegible]	55.00	65.00

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$0.72	$0.80	$0.76

WHITE AND RED LEAD—Base price per pound:

	Red				White	
	Current		1 Year Ago		Current	1 Yr. Ago
	Dry	In Oil	Dry	In Oil	Dry and In Oil	Dry and In Oil
100-lb. keg	12.25	13.75	15.50	17.00	12.25	15.50
25- and 50-lb. keg	12.50	14.00	15.75	17.25	12.50	15.75
12½-lb. keg	12.75	14.25	16.00	17.50	12.75	16.00
5-lb. cans	15.25	16.75	18.50	20.00	15.25	18.50
1-lb. cans	17.25	18.75	20.50	22.00	17.25	20.50

RIVETS—The following quotations are allowed for fair-sized orders from ware house:

	New York	Cleveland	Chicago
Steel ⅛ and smaller	50–10%	60–10–10%	60–10%
Tinned	50–10%	60–10–10%	4½c. per lb. net

Structural rivets, ¾, ⅞, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.

New York	Chicago	Pittsburgh
$3.70	$3.68	$2.40

Boiler rivets, same sizes:

New York	Chicago	Pittsburgh
$3.80	$3.78	$2.50

REFRACTORIES—Prices in carlots:

Chrome brick, eastern shipping points	net ton	$50.00
Chrome cement, 40@45% Cr_2O_3	net ton	25.00
Chrome cement, 40@45% Cr_2O_3 in sacks	net ton	27.50
Magnesite brick: 9-in. straight	net ton	60.00
Magnesite brick: 9-in. arches, wedges and keys	net ton	66.00
Magnesite brick: Soaps and splits	net ton	84.00
Silica brick: Chicago district	per 1,000	38.00
Silica brick: Birmingham, Ala	per 1,000	43.00@46.00
Silica brick: Mt. Union, Pa	per 1,000	33.00

BABBITT METAL—Warehouse prices in cents per pound:

	New York	Cleveland	Chicago
Best grade	70.00	39.00	34.00
Commercial	30.00	13.50	8.00

COLD FINISHED STEEL—Warehouse prices are as follows:

	New York	Chicago	Cleveland
Round shafting or screw stock, per 100 lb. base	$3.88	$3.83	$3.50
Flats, square and hexagons, per 100 lb. base	4.38	4.35	4.00

BOILER SPECIALTIES—F. o. b. New York or Jersey City, discounts on list:

	Current
Copper ferrules	75%
Boiler flanges	55%
Boiler stay bolts	60%
Boiler patch bolts	Net list
Boiler fitting-up bolts	50%
Pressed steel boiler lugs	10%
Pressed steel boiler hangers	10%

WROUGHT PIPE—The following discounts are to jobbers for carload lots on the latest Pittsburgh basing card:

BUTT WELD

Inches	Steel Black	Galv.	Inches	Iron Black	Galv.
1 to 3	68½	56	⅛ to 1½	44½	29½

LAP WELD

2	61½	49	2	39½	25½
2½ to 6	65½	53	2½ to 4	42½	29½
7 to 8	62½	49	4½ to 6	42½	29½
9 and 12	62½	49	7 to 12	40½	27½

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	66½	55	1 to 1½	44½	30½
2 to 3	68½	56			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	59½	48	2	40½	27½
2½ to 4	63½	52	2½ to 4	43½	31½
4½ to 6	62½	51	4½ to 6	42½	30½
7 to 8	58½	45	7 to 8	35½	23½
9 to 12	52½	39	9 to 12	30½	18½

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$0.22
1¼	.....	.....	.21
1½	.....	.....	.1755
1¾	$0.2134	$0.2404	.1936
2	.1638	.2069	.1701
2¼	.1872	.2364	.1944
2½	.1950	.2768	.2280
2¾	.2216		.2584
3	.2470	.3505	.2698
3¼	.2610	.4039	.2925
3½	.2784	.4308	.3120
4	.3538	.5475	.3965

Tubes 2¼ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.

These prices are net per lineal foot based on stock lengths. If cut to special lengths, billing will be based on the entire stock lengths.

In addition to the above, standard cutting charges are as follows:

1¼ in. to 2 in. diameter, 5c. per cut. 2¾ in. diameter, 7c. per cut
2½ in. diameter, 6c. per cut. 3 in. diameter, 9c. per cut
3¼ in. to 4 in. diameter, 10c.

ELECTRICAL SUPPLIES

ARMORED CABLE—

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$ 43.00(net)	$138.00	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:

Less than coil lots	25%	15%
Coils to 1,000 ft.	35%	30%
1,000 ft. and over	45%	35%

BATTERIES, DRY—Regular No. 6 size red seal, Columbia, or Ever-Ready:

	Each, Net
Less than 12	$0.40
12 to 50	.34
50 to 125 (bbl.)	.30½
125 (bbl.) or over	.29

CONDUIT, Price per 1,000 ft.; ELBOWS AND COUPLINGS, Per 100 pieces, f. o. b. New York, with 10-day discount of 5 per cent.

Size, In.	Conduit Black 2,500 to 5,000 Lbs.	Conduit Galvanized 2,500 to 5,000 Lbs.	Elbows Black 2,500 to 5,000 Lbs.	Elbows Galvanized 2,500 to 5,000 Lbs.	Couplings Black 2,500 to 5,000 Lbs.	Couplings Galvanized 2,500 to 5,000 Lbs.
¼	$54.23	$59.33	$11.36	$12.50	$4.82	$5.24
⅜	69.92	76.82	14.95	16.45	6.88	7.48
½	99.96	110.16	22.13	24.35	8.94	9.72
¾	135.24	149.04	29.16	31.86	12.55	13.57
1	161.70	178.20	38.88	42.48	15.50	16.76
1¼	217.56	239.76	71.28	77.88	20.66	22.34
1½	343.98	379.08	116.64	127.44	29.52	31.92
2	449.82	495.72	311.04	339.84	44.28	47.88
2½	568.56	623.76	686.88	750.48	59.04	63.84
3	695.42	760.82	793.80	867.30	73.80	79.80

CONDUIT NON-METALLIC, LOOM—

Size I. D., In.	Feet per Coil	List, Ft.
⅛	250	$0.05½
¼	250	.06
⅜	250	.09
½	200	.12
¾	200	.15
¾	150	.18
1	100	.25
1¼	100	.33
1½	Odd lengths	.40
2	Odd lengths	.55

1000 ft. and over.... 65%
Coils..... 55%
Less coils, 45%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.08	D. P. D. B.	$0.32
D. P. M. L.	.15	T. P. to D. P. S. B.	.18
T. P. M. L.	.23	T. P. S. B.	.29
D. P. S. B.	.17	T. P. D. B.	.47

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.40	$1.08	$1.35
T. P. M. L.	.57	1.50	1.95
D. P. S. B.	.51	1.35	.....
T. P. S. B.	.96	1.90	.....
D. P. D. B.	.72	2.45	.....
T. P. D. B.	1.58	4.40	.....
T. P. to D. P. D. B.	1.06	3.10	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$12.50
No. 16 cotton twisted	15.75
No. 18 cotton parallel	14.50
No. 16 cotton parallel	18.00
No. 18 cotton reinforced heavy	20.50
No. 16 cotton reinforced heavy	24.00
No. 18 cotton reinforced light	18.75
No. 16 cotton reinforced light	22.00
No. 18 cotton Canvasite cord	15.00
No. 16 cotton Canvasite cord	17.75

FUSES, ENCLOSED—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.,	100	$0.25	3-amp. to 30-amp.,	100	$0.40
35-amp. to 60-amp.,	100	035	35-amp. to 60-amp.,	100	.60
65-amp. to 100-amp.,	50	.90	65-amp. to 100-amp.,	50	1.50
110-amp. to 200-amp.,	25	2.00	110-amp. to 200-amp.,	25	2.50
225-amp. to 400-amp.,	25	3.60	225-amp. to 400-amp.,	25	5.50
425-amp. to 600-amp.,	10	5.50	450-amp. to 600-amp.,	10	8.00

Discount: Less 1-5th standard package, 50%; 1-5th to standard package, 55%; standard package, 65%.

RENEWABLE FUSES, ENCLOSED—

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50 ea.	$1.10 ea.	100	10
35 to 60-amp.	1.00 ea.	1.25 ea.	100	10
65 to 100-amp.	2.00 ea.	3.00 ea.	50	5
110 to 200-amp.	4.00 ea.	5.00 ea.	25	5
225 to 400-amp.	7.50 ea.	11.00 ea.	25	1
450 to 600-amp.	11.00 ea.	16.00 ea.	10	1
450 to 600-amp.	11.00 ea.	16.00 ea.	10	1

RENEWAL LINE FOR ABOVE FUSES—

1 to 30	$0.30 ea.	$0.05	100	100
35 to 60	.05 ea.	.06	100	100
65 to 100	.10 ea.	.10	50	50
110 to 200	.15 ea.	.15	25	50
225 to 400	.30 ea.	.30	25	25
450 to 600	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package	$3.00
0-30 ampere, less than standard package	3.25

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shaped Bulbs Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.40	$0.45	100	75	$0.75	$0.80	50
15	.40	.45	100	100	1.10	1.20	24
25	.40	.45	100	150	1.55	1.65	24
40	.40	.45	100	200	2.10	2.25	24
50	.40	.45	100	300	3.15	3.35	24
60	.45	.50	100				12
				500	4.60	4.85	12
				750	6.50	6.85	8
				1,000	7.50	7.85	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.21
Composition 2-piece attachment plug	.28
Swivel attachment plug	.14
Current taps	.40

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York.

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$ 6.00	$ 7.80	$9.00	$14.50
12	8.00	10.20	11.95	19.20
10	10.95	12.75	15.20	24.68
8	14.25	16.60	19.50	32.91
6	.....	.....	29.35	.....
4	.....	.....	39.30	.....
2	.....	.....	55.00	.....
1	.....	.....	74.32	.....
0	.....	.....	93.00	.....
00	.....	.....	111.64	.....
000	.....	.....	133.72	.....
0000	.....	.....	159.52	.....

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap Key Each	Keyless Each	Pull Each	¾ In. Cap Key Each	Keyless Each	Pull Each
$0.33	$0.30	$0.60	$0.39	$0.36	$0.66

Less 1-5th standard package	15%
1-5th to standard package	30%
Standard package	45%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B. & S. regular spools (approx. 8 lb.)	33c. lb.
No. 18 B. & S. regular 1-lb. coils	34c. lb.

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	32c. lb
Rubber tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	31c. lb.
Wire solder, less 100 lb. 27c. lb., 100 lb. lots	23c. lb
Soldering paste, 2 oz. cans	$1.50 doz

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$0.42	$0.68	$1.02	$1.36
60	.74	1.22	1.84	2.44
100	1.50	2.50	3.76	5.00
200	2.70	4.50	6.76	9.00
TYPE "C" FUSIBLE, TOP OR BOTTOM				
30	70	1.06	1.60	2.12
60	1.18	1.80	2.70	3.60
100	2.38	3.66	5.50	7.30
200	4.40	6.76	10.14	13.50

Discounts:	
Less than $10.00 list value	+5%
$10 to $25 list value	10%
$25 to $50 list value	15%
$50 to $200 list value	25%
$200 list value or over	30%